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# RIO COUNTRY REPORT 2015: China

Can Huang
Xiao Jin
Lanhua Li

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**Contact information**
Address: Edificio Expo. c/ Inca Garcilaso, 3. E-41092 Seville (Spain)
E-mail: jrc-ipts-secretariat@ec.europa.eu
Tel.: +34 954488318
Fax: +34 954488300

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**Abstract**
RIO R&I International Country Reports analyse and assess the research and innovation system, including the main challenges, framework conditions, regional R&I systems, and international co-operation.

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# Foreword

The report offers an analysis of the R&I system in China for 2015, including relevant policies and funding. The report identifies the main challenges of the Chinese research and innovation system and assesses the policy response. It was prepared according to a set of guidelines for collecting and analysing a range of materials, including policy documents, statistics, evaluation reports, websites etc.

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Author's affiliation:

Can HUANG et al., School of Management, Zhejiang University, Hangzhou, P.R. China

## Executive summary

The People's Republic of China has experienced rapid economic growth over the last three decades. However, growth has slowed in the recent years. The GDP annual growth rate dropped from 9.5% in 2011 to 6.9% in 2015 (OECD, 2015; National Bureau of Statistics of China, 2016). By 2014, China was the second largest economy in the world with GDP of €7.78 trillion (RMB 63.5 trillion) or € 9,913 ($13,170) per capita (current prices and PPPs, OECD, 2015)[1]. Home to a fifth of the world's population, China is the most populous country in the world.

In 2005 China became the world's second largest spender on R&D. In 2014, Gross Expenditure on R&D (GERD) in China reached €277.6 billion (USD 368.7 billion, current price and PPPs). The GERD increased from €178.0 billion (USD 247.8 billion, current prices and PPPs) in 2011 to €277.6 billion (USD 368.7 billion, current prices and PPPs) in 2014, representing 56% of increase over the four years (OECD,2015). The R&D expenditure performed by industry, Public Research Institutions (PRO), and Higher Education Institutions (HEI) amounted to €123.2 billion (RMB 1.0 trillion), €23.6 billion (RMB 192.6 billion) and €11.0 billion (RMB 89.8 billion), which correspond to 77.3%, 14.8% and 6.9% of the GERD. China possesses the largest S&T workforce in the world, which is composed of 5.35 million R&D personnel or 3.71 million full-time equivalent in 2014, including 0.32 million PhDs. (China Statistical Yearbook on Science and Technology, 2015).

The Chinese government's 12th Five-Year Plan (2011-2015) specifies an R&D intensity target over 2.2% of GDP by 2015, a stepping stone towards investing 2.5% of GDP on R&D by 2020, which is a target set in The Medium- and Long-term National Plan for Science and Technology Development: 2006–2020 (hereinafter MLP). The actual GERD to GDP ratio increased from 1.79% in 2011 to 2.08% in 2015, though it did not meet the target set in 12th Five-Year Plan. Another indicator on S&T development specified in the 12th Five-Year Plan was the number of invention patents per 10,000 population. The target was set to reach 3.3 in 2015, but the actual number in 2015 is 6.3, well surpassing the target. The 13th Five-Year Plan (2016-2020) maintains these two indicators as the key ones to guide the S&T development and iterates the target of having the GERD to GDP ratio reaching 2.5% in 2020. However, the target of number of invention patents per 10,000 population is increased to 12 by 2020.

At the 18th National Congress of the Chinese Communist Party (CPC) held in November 2012, the Chinese leadership called for pursuing innovation-driven development strategy. It is emphasized that economic development in China would be driven more by domestic demand, especially consumer demand, by a modern service industry and strategic emerging industries, by scientific and technological progress, by a workforce of higher quality and innovation in management, by resource conservation and a circular economy, and by coordinated and mutually reinforcing urban-rural development and development between regions. In the Third Plenary Session of the 18th CPC Central Committee held in November 2013, the decision was made to deepen the comprehensive reform in the country in order to pursue the innovation-driven development strategy. Since late 2013, several major policies and law amendments have been announced to accelerate the implementation of the strategy, and address the major challenges in China's innovation system.

Second, a major weakness of the Chinese innovation system is the fragmentation of the funding system. In January 2015, the Chinese government announced an overhaul of the S&T financing system, which is to be finished by 2017. One of the objectives of the reform is to reduce fragmentation and enhance harmonization of the S&T funding

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[1] The exchange rate used in this report is Euro:RMB=1:8.1651, 1:8.2219, 1:8.1067 and 1:9.0011, in 2014, 2013, 2012 and 2011, respectively (China Statistical Yearbook, 2015) and Euro:USD=1: 1.392, 1: 1.2848, 1.3281 and 1.3285, in 2011, 2012, 2013 and 2014, respectively (Eurostat, 2016).

system. The government will integrate more than 90 funding programmes managed by some 40 government departments into five major ones, which include the National Natural Science Foundation of China (NSFC), National Science and Technology Major Project, National R&D Key Program, Technological Innovation Introductory Fund and Base and Talent Program. In the old system, each government agency manages its R&D programmes separately. Duplicate research may have been conducted due to a lack of communication between funding organizations. In the new system, a joint committee will be established to oversee fund allocation, aiming to increase communication among government departments. The representatives of the ministries such as Ministry of Science and Technology (MOST), Ministry of Finance and National Development and Reform Commission (NDRC) will be the members. The joint committee will allow members from different government agencies to discuss funding priorities and management of the projects.

Third, another weakness of the S&T funding system before the reform of 2015-2017 was that in the old system, the government departments have the power to both distribute public research funds and supervise their use, which can easily lead to corruption. In the new system, government departments will not manage research projects. Instead, independent and professional organizations will be created to select the applications and manage the funded projects. The organizations will have to compete with each other to gain the service contracts offered by the government agencies.

Fourth, in spite of significant investment in R&D in Chinese universities, Chinese universities' patent technology transfer rates remain low, ranging from 2 percent (People's Daily 2015) to 5 percent (MOE 2015) annually. The national rate is 10 percent (NBD 2014). Besides technology maturity gaps between universities' basic R&D research and industry's commercial applications, one of the main reasons for such a low technology transfer rate is a flawed regulatory system, which suffers from shortcomings involving incentives, ownership and decision-making authority, protection, policy impediments, and distribution of profits.

Firstly, although China has invested intensively in R&D and Chinese companies have taken large market shares in many products, Chinese scientists have not yet reached the frontier of scientific research except in a few fields, Chinese companies have yet been able to enter some high value-added niche markets, for certain key components and equipment which has profound impact on national security, China is still reliant on foreign products and technologies. To tackle this challenge, after the MLP was launched in 2006, the Chinese government soon started the National Science and Technology Major Project to support R&D in technologies such as general purpose computer chip, wireless communication, high-precision machine tools, nuclear power, and HIV/AIDS treatment. In the 12$^{th}$ Five-Year Plan and 13$^{th}$ Five-Year Plan, the Chinese government has funded and will continue to sponsor the research in these frontier technology fields and also the projects that are the key to the national security and industrial competitiveness.

As one of the measures to tackle the challenge, the Law on Promoting the Transformation of Scientific and Technological Achievements was amended in August 2015 and came into force on October 1st, 2015. The original law was passed in 1996. The amendment 20 years after its passage aims to promote technology transfer from public research organizations and higher education institutions, incentivize R&D staff in the public research organizations and higher education institutions to start their own businesses and make innovations, and also create good policy environment for technology transfer. The new law clarifies IP ownership and decision-making authority over patents and technology, reduces legal risks associated with the transfer or sale of university-owned IP, and removes the policy impediments to university researchers' entrepreneurial start-ups and eventual public listing.

China's research and innovation policies are instituted in a top-down manner, in which the central government frequently sets goals and objectives for S&T development. Investment in research follows a national strategy of building indigenous innovation capabilities[2] and addressing societal challenges, reflected by priorities in industrial competitiveness, energy, environment, agriculture, and healthcare. The rationale for priority setting is that the government should concentrate limited resources on certain areas that the country and the industry urgently needs breakthroughs, avoiding that are resources are too thinly spread.

Regional governments (provinces, municipalities) in China are granted a high degree of autonomy for regulating and managing the local economy and society. Sub-national governments contribute about one-third of the total government investment in R&D. However, in terms of priority and agenda setting in the R&I policy, the central government is more authoritative than the local governments. The most important policies and guidelines are discussed and enacted at the level of the central government. Once the national plan and objective is set, the individual provinces or cities will make their respective plans and strategies, echoing the national strategy. In terms of S&T funding, the economically developed provinces can appropriate substantial budget to finance S&T activities, as the top five Chinese provinces can be ranked in between 16$^{th}$ to 28$^{th}$ position in the world by the size of GDP. In the provincial governments, specialized departments such as the Commission of Science and Technology of Beijing municipal government, the Commission of Science and Technology of Shanghai municipal government and the Department of Science & Technology of Guangdong provincial government, are responsible for management S&T funding within their purview, similar as the Ministry of Science and Technology overseeing a large amount of S&T investment by the central government.

China has established science and technology cooperation with the European Union (EU) since the signing of EU-China Science and Technology Agreement in 1998. A multitude of formal science and technology agreements have been instituted between China and Europe at both the EU and individual Member State level. These agreements promote scientific exchange, research collaboration and coordination among national authorities. Chinese researchers are active participants in the EU Framework Programmes. The future efforts would be needed in the area that both sides saw opportunities and the strengths are complementary. Given that the landscape of R&D activities in China is rapidly changing, and both the European and Chinese sides are continuing to define each other's own priorities, it would be important for both governments to continuously monitor general trends, study new developments, and engage in discussion.

[2] Indigenous Innovation is a term frequently used by the Chinese government in R&D policies. The main document mentioning Indigenous Innovation is The Medium- and Long-term National Plan for Science and Technology Development: 2006–2020. There are three principal definitions about Indigenous Innovation: First, promoting Chinese original innovation and creating more national technological inventions; second, enhancing the ability to integrate technologies and developing national competitive products, as well as companies and industries; third, enhancing the ability to learn and recreate imported technologies (MOST, 2006a).

# R&I Fact sheet
# China

**Table 1 –** General Data

| Indicator | China[3] | EU-28 |
|---|---|---|
| Number of inhabitants (Million) | 1,367.82 | *506.6* |
| GDP MEUR | 7,788,200 | *13 068 600* |
| GDP per head (index, EU28 = 100<br>EUR per capita) | 21.5<br>5,711 | *100*<br>*26 600* |
| Real GDP growth rate (%) | 7.4% | *0.1%* |
| Agriculture weight in the economy (%) | 9.5% (GVA[4])<br>29.5% (employment) | *1.7%*<br>*5.1%* |
| Industry & construction weight in the economy (%) | 42.7% (30.1%) manufacturing (GVA)<br>29.9% (N/A) manufacturing (employment) | *24.8% (15.1%)*<br>*22.4% (14.3%)* |
| Services weight in the economy (%) | 48.1%(GVA)<br>40.6% (employment) | *73.6%*<br>*72.4%* |
| Employment rate, aged 20-64 (% of population) | N/A | *68.4%* |
| Unemployment rate (% of the active population) | 4.09% | *10.9%* |
| Early leavers from education and training (% of population aged 18-24) | N/A | *11.9%* |
| | Target 2020: N/A | *Target 2020:10%* |
| Tertiary educational attainment (% of population aged 30-34) | N/A | *37.1%* |
| | Target 2020: N/A | *Target 2020: 40%* |
| Total government expenditure (MEUR % of GDP) | 1,859,000 | *6 412 328* |
| | 23.9% | *49.1%* |
| General government gross debt (% of GDP) | 39.2% | *87.1%* |
| General government deficit (% of GDP) | 9.8% | *-3.3%* |
| Human Development Index (HDI), Source: UNDP | 0.727 | *EU max (NL): 0.915*<br>*EU min (BG): 0.777* |
| PISA Ranking, Source: OECD, 2013 (reading; mathematics; science) | Shanghai-China is ranked 1st in the PISA 2012 Result. | -- |

[3] Source: China Statistical Yearbook 2014 Issue; Exchange rate is RMB 8.1651 =1 Euro.
[4] Gross Value Added (GVA) at basic prices equals GDP minus taxes on products plus subsidies on products.

**Table 2** - Institutional Structure of the Research and Innovation System

| | |
|---|---|
| **MINISTRIES RESPONSIBLE** | Ministry of Science and Technology<br>National Development and Reform Commission<br>Ministry of Industry and Information Technology<br>Ministry of Education<br>Ministry of Finance |
| **NAME OF MINISTER** | **Wan Gang -** Ministry of Science and Technology<br>**Xu Shaoshi –** National Development and Reform Commission<br>**Miao Wei -** Ministry of Industry and Information Technology<br>**Yuan Guiren-** Ministry of Education<br>**Lou Jiwei -** Ministry of Finance |
| **ADVISORY BODY** | Chinese Academy of Science<br>Chinese Academy of Social Sciences, CASS<br>Chinese Academy of Engineering<br>Development Research Centre of The State Council |
| **FUNDING AGENCIES** | National Natural Science Foundation of China – http://www.nsfc.gov.cn/ |
| | Ministry of Science and Technology – http://www.most.gov.cn/eng/index.htm |
| | National Development and Reform Commission – http://en.ndrc.gov.cn/ |
| | Ministry of Industry and Information Technology – http://www.miit.gov.cn/ |
| | Ministry of Education – http://en.moe.gov.cn/ |
| | Ministry of Agriculture – http://english.agri.gov.cn/ |

Investment & HR & Infrastructures

Investment and flows

| | |
|---|---|
| Gross domestic R&D expenditure (GERD) | € 277,555 million; 2.05% of GDP;<br>TARGET 2020: 2.5% |

Source: OECD 2014

**Figure 1** - GERD trend in millions and as % of the GDP

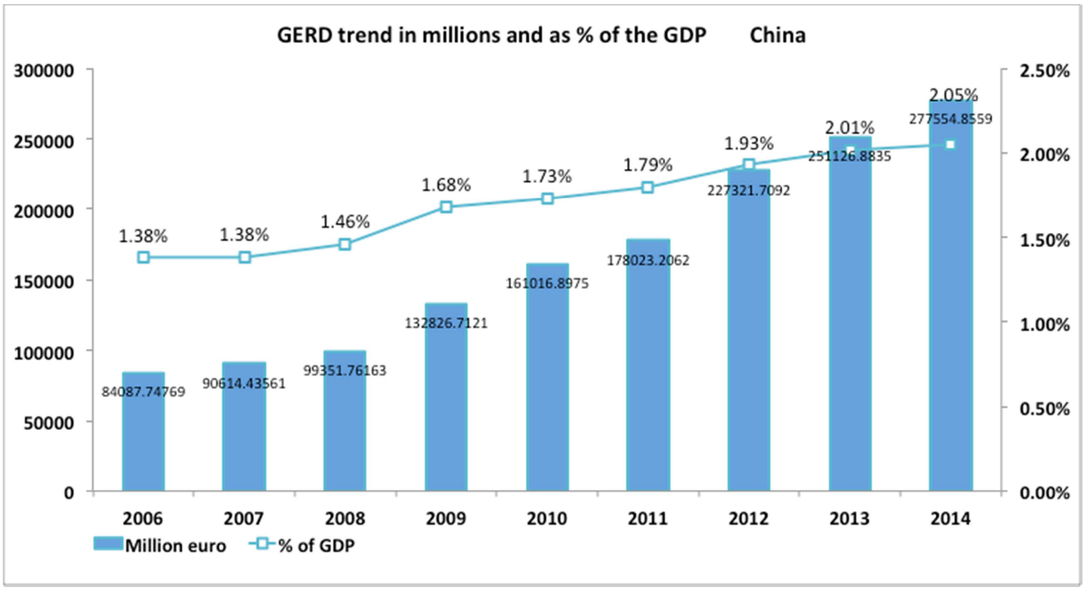
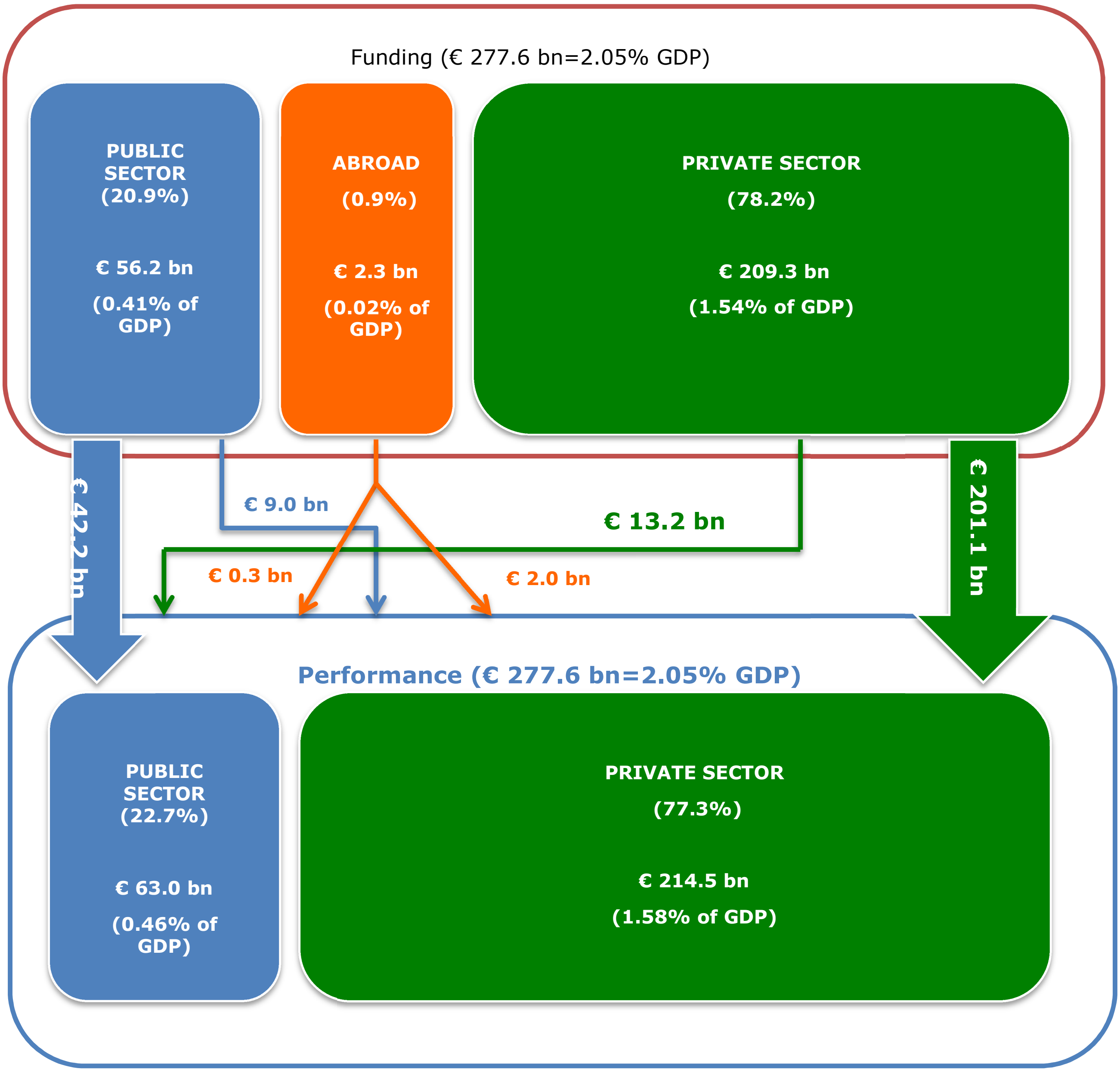



**Table 3** - R&D Sources of Funding and Expenditure

| **R&D SOURCES OF FUNDING**[1] | EUR / % |
|---|---|
| Total R&D expenditure financed by government (2014) | € 56,213.7 million (0.41% of GDP) |
| Total R&D expenditure financed by business enterprise (2014) | € 209,334.5 million (1.54% of GDP) |
| Total R&D expenditure financed by abroad (2014) | € 2,293.5 million (0.02% of GDP) |
| **PUBLIC EXPENDITURE** | |
| Total public sector R&D expenditure (GOV&HES) (2014)[2] | € 63,014.5 million (0.46% of GDP) |
| GBAORD (2014)[3] | € 32,284.7 million (0.41% of total government expenditure) |
| GBAORD for defence (2014) | N/A |
| **PRIVATE EXPENDITURE**[4] | |
| Total private sector R&D expenditure (BES&PNP) (2014) | € 214,540.4 million (1.58% of GDP) |
| BERD (2014) | € 214,540.4 million (1.58% of GDP) |

- Sources: Data for the indicators with superscript 1, 2 and 10 are from OECD (2015), and for the indicators with superscript 3 is from National Audit Office of China (2015).
- Note: The units of expenditure are current prices and PPPs.

**Figure 2** – Flows of R&D funds in China (2014)




Data source: OECD (2015)

Note:

1. The "public sector" in performance box includes public research organizations affiliated with government and higher education institutions. However, the "public sector" in the funding box includes only government.
2. The flow of R&D funds in China is characterized by a high share of private sector funding (almost two-thirds of total expenditure). In 2014 BES amounted to 209,334.5 million EUR (278,101 USD, current prices and PPPs), more than triple that of the public sector funding. Funding from abroad amounts to 0.02% of GDP. The share of private sector performance in R&D is 1.58% while the public sector performance accounts for 0.46% of GDP.

**Table 4** - Human Resources & Research Infrastructures

| Human Resources in S&T / R&D personnel | Number/FTE (%) |
|---|---|
| Human resources in S&T activities (2014) | 3.71 million |
| Scientists & engineers (2009) | 1.15 (% of total) |
| Researchers in the private sector (2014) | 2.64 million (71% of total researchers) |
| Researchers in the public sector (2014) | 0.58 (16% of total researchers) |
| Female researchers (2014) | 305,000 (40.0% of total researchers)[1] |
| **Research Infrastructures** | |
| Number of key RIs | More than 10 |
| Involvement in international RI | N/A |
| Higher education system (2014) | 2529 Universities |

Note:

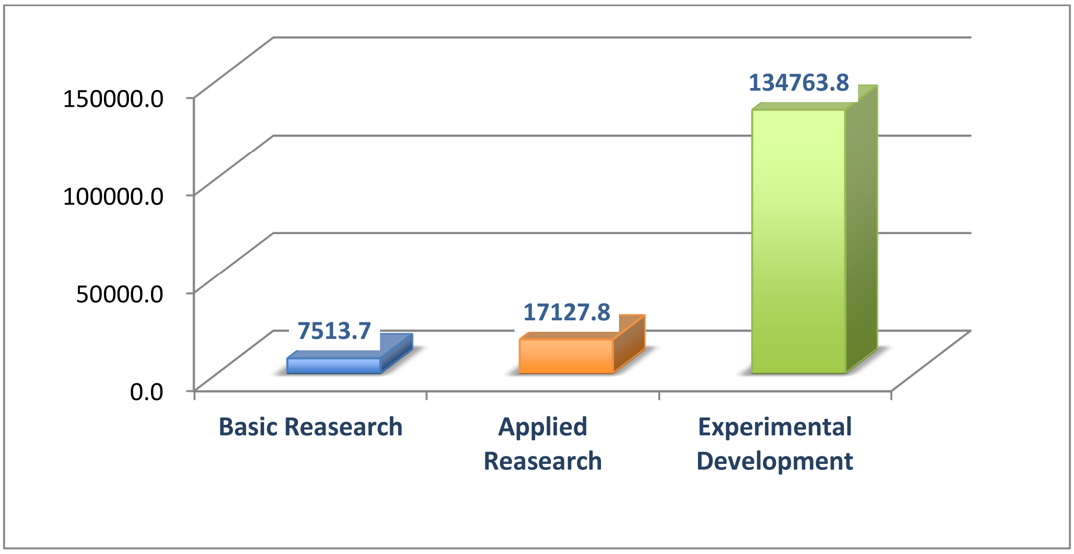
The data are for female researchers in higher education institutions only.

Data are from National Bureau of Statistics of China.

Framework conditions for knowledge-intensive economy

Investment process & conditions in China

**Figure 3** - R&D expenditure per R&D type of activity (MEUR, 2011)




Data: National Bureau of Statistics of China

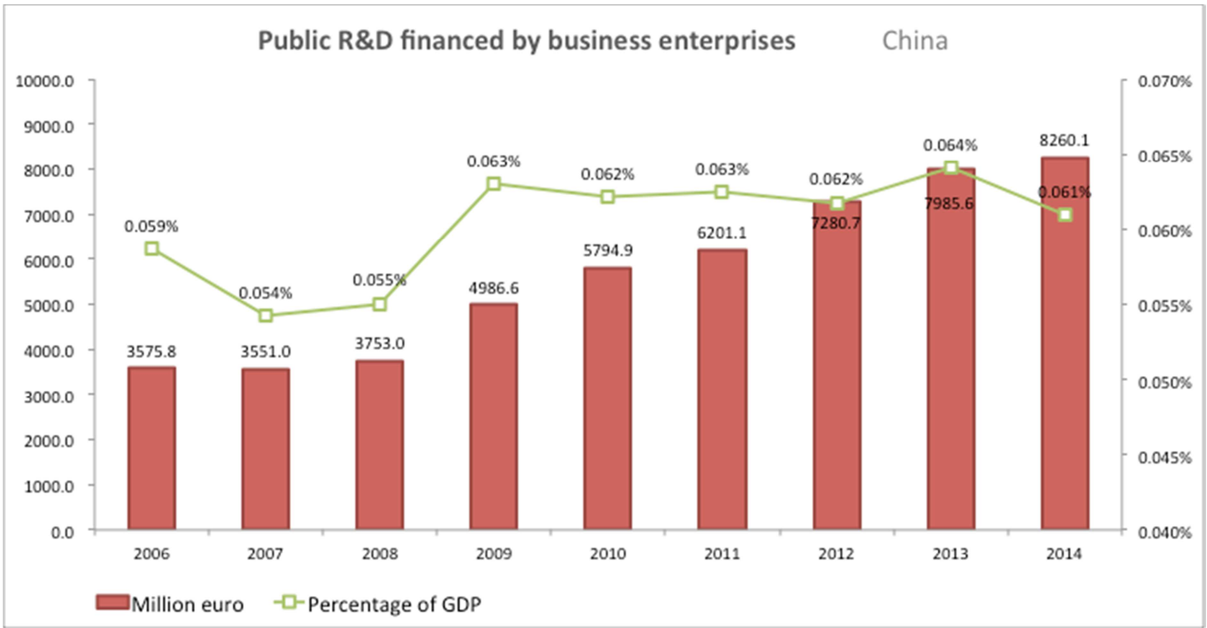
**Table 5**: – Investment process and conditions

| | |
|---|---|
| Broadband – Households having access to the internet (2015) | 40% |
| High-tech exports (2014) | 35.3% (of total export) |
| Inward FDI stock (2014) | € 158,835.46 million (1.15% of GDP) |
| Venture Capital (2014)[1] | €13,864 million (% of GDP) |
| Public expenditure in the field of education (2014) | € 282,197.5 million (15.2% of total government expenditure) |
| Total number of students (2014)[2] | 33,855,900 |
| Female students (2014) | 17,851,599 |
| Students in scientific fields STEM (2014) | 17,984,899 (54.9% of total) |
| New graduates from tertiary education (2014) | 9,341,863 |

Data: National Bureau of Statistics of the People's Republic of China

Notes: 1. Source: Down Jones VentureSource; 2. Number of students in universities and colleges.

**Figure 4**- Public R&D financed by business enterprises




Note:

Data: OECD database, 2014.

In 2014, privately funded public R&D in China was 0.061% of GDP, which suggests a medium level of science-business collaboration. In absolute terms, the privately funded public R&D has kept increasing in the period of 2007-2014.

**Table 6** - Innovation outputs & impact

| Bibliometrics[1]: | Number / Score (% / Rank) |
|---|---|
| Publications (2014) | 1.57 million |
| Average relative citations (2005-2015) | 12.88 million |
| Share of international co-publications (2013) | 15.4%. |
| Percentage of Top-10% Most Highly Cited Publications (2010) | 7.4% |
| Patents/Trademarks/Industrial designs[2] | Number / Score (% / Rank) |
| Patents (applications, for resident, 2014) | 801,135 (86.3% of total) |
| Patents (granted, for resident, 2014) | 162,680 (69.8% of total)) |
| PCT patent applications (receiving, WIPO, 2014) | 27,088 |
| PCT top applicants (WIPO, 2013) | *HUAWEI TECHNOLOGIES (rank 1); ZTE CORPORATION (rank 3); BOE TECHNOLOGY GROUP (rank 14); TENCENT TECHNOLOGY (SHENZHEN) (rank 20)* |
| Trademark applications (WIPO, for residents, 2014) | 2,076,472 (Rank 1) |
| Trademark registrations (WIPO, for residents, 2014) | 1,242,843 (Rank 1) |
| Industrial design applications (WIPO, for residents, 2014) | 548,428 (Rank 1) |
| Industrial design registrations (WIPO, for residents, 2014) | 346,751 (Rank 1) |
| Composite indicators[3] | |
| Research excellence composite indicator (2014) | N/A (EU-28: 47.8) |
| Innovation Output Indicator (2014) | 46.57 (EU: 21). |
| Innovation Union Scoreboard (2014) | 0.301 (EU: 0.613) |
| Global Innovation Index (2014) | 47.47 (rank 29) |
| PhD graduated (2014)[4] | 53,653 |
| Turnover from innovation (2014) | N/A (EU-28: 11.9) |
| Enterprises that have introduced new products to the market (2014)[5] | 17,075 |
| Employment in knowledge intensive activities (2010) [6] | 10,361,895 (14.5% of total employment) |
| Employment in medium-high and high-tech manufacturing (2014) | N/A (% of total employment) |

Note:

Data for the indicators with superscript 1, 4, 5 and 6 are from National Bureau of Statistics of the People's Republic of China.

Data for the indicators with superscript from World Intellectual Property Indicators 2015.

Data for the indicators with superscript from The Global Innovation Index 2015

# 1. Overview of the R&I system

## 1.1 Introduction

China is the most populous country in the world with a population of 1377 million, nearly three times of the EU28 (508 million population). The land area of China is almost twice that of the EU (Eurostat, 2015). China is the world's second largest economy whose GDP reached €7.78 trillion (RMB 63.5 trillion). As the result of the post financial crisis stimulus package, China is going through a transition from rapid development (2011 annual GDP growth rate at 9.49%) to a slower but more sustainable economic growth rate of 7.25% in 2014, which is higher than EU (2014 annual GDP growth rate at 1.3%). However, GDP per capita of China (2014: 9,913 EUR) is much lower than EU average (2014: 27,300 EUR) (OECD, 2015).

In 2014, government debt of China is 39.2% of GDP, increasing from 36.7% in 2012 and having a general increasing trend. The unemployment rate of the labour force is around 4% over the past 3 years, relatively lower than that of the EU28 (China Statistical Yearbook, 2015).

As for the economic structure of China, the shares of primary, secondary and tertiary industry in the GDP are 4.8%, 47.1% and 48.1% in 2014 (China Statistical Yearbook, 2015). Innovation plays an increasing role in the Chinese economy as China became the world's second largest spender on R&D in 2005. In fact, China's R&D intensity has increased steadily in the past decade. The country's commitment to R&D investment was not even affected during the global financial crisis during the period of 2008-2009. The Gross Expenditure on R&D (GERD) amounted to €277,554 million (USD 368,731 million, current prices and PPPs) in 2014 and R&D intensity (GERD as percentage of GDP) increased from 1.93% in 2012 to 2.05% in 2014, surpassing the level of the EU28 (2014: 1.94%) (OECD, 2015).

In China, industry is the main actor of performing R&D, spending 77% of GERD in 2015 (National Bureau of Statistics of China, 2015). The Business Expenditure on R&D (BERD) to GDP ratio was 1.58% in 2014, increasing from 1.36% in 2011 (OECD, 2015).

**Table 7 -** Main R&I indicators 2012-2014

| Indicator | 2012 | 2013 | 2014 | EU average 2014[9] |
|---|---|---|---|---|
| GDP per capita[1] | 8,707 EUR (11,187 USD) | 9,161 EUR (12,166 USD) | 9,913 EUR (13,171 USD) | 27,300 EUR |
| GDP growth rate[2] | 7.75% | 7.69% | 7.25% | 1.3% |
| Budget deficit as % of public budget[3] | 9.8 | 14.8 | 14.8 | 86.8 |
| Government debt as % of GDP[4] | 36.7 | 35.2 | 39.2 | -2.9 |
| Unemployment rate as percentage of the labour force[5] | 4.1 | 4.05 | 4.09 | 10.2 |
| GERD in €m[6] | 227,322 (292,063 USD) | 251,127 (333,522 USD) | 277,555 (368,732 USD) | 268,672 |
| GERD as % of the GDP[7] | 1.93 | 2.01 | 2.05 | 1.936 |
| GERD (EUR per capita)[8] | 165 | 181 | 199 | No data |
| Employment in high- and medium-high-technology manufacturing | N/A | N/A | N/A | 5.6 (2013) |

| | | | | |
|---|---|---|---|---|
| sectors as share of total employment | | | | |
| Employment in knowledge-intensive service sectors as share of total employment | N/A | N/A | N/A | 39.2 (2013) |
| Turnover from innovation as % of total turnover | N/A | N/A | N/A | 11.9 (2012) |
| Value added of manufacturing as share of total value added | N/A | N/A | N/A | No data |
| Value added of high tech manufacturing as share of total value added | N/A | N/A | N/A | No data |

Data:

- Data for the indicators with superscript 1, 2, and 6 are from OECD, 2015.
- Data for the indicators with superscript 3 are from National Audit Office of the People's Republic of China, 2015.
- Data for the indicators with superscript 4 and 5 are from National Bureau of Statistics of China, 2015.
- Data for the indicators with superscript 7 and 8 are authors' calculation based on the data from OECD, 2015.
- Data for the indicators with superscript 9 are from OECD, 2015 and Eurostat, 2015.
- The units of GDP per capita, GERD in €m and GERD (EUR per capita) are current prices and PPPs.

The economic growth in China slowed down in the recent years. The GDP annual growth rate dropped from 9.5% in 2011 to 6.9% in 2015 (OECD, 2015; National Bureau of Statistics of China, 2016), entering in a stage that the Chinese leadership called "new normal". As China faces challenges of sustaining its economic growth and social development, in 18th National Congress of the Chinese Communist Party (CPC) held in November 2012, the Chinese leadership called for pursuing innovation-driven development strategy. Launching the strategy, the Chinese leadership clearly realized that China can no longer rely on investment-driven strategy or low-cost manufacturing without environment protection or reservation to sustain economic growth. The strategy emphasizes that economic development in China would be driven more by domestic demand, especially consumer demand, by a modern service industry and strategic emerging industries, by scientific and technological progress, by a workforce of higher quality and innovation in management, by resource conservation and a circular economy, and by coordinated and mutually reinforcing urban-rural development and development between regions. In the Third Plenary Session of the 18th CPC Central Committee held in November 2013, the decision was made to deepen the comprehensive reform in the country in order to pursue the strategy. Guided by the overarching innovation-driven development strategy, China has strengthened the R&D investment and continued to provide incentives for innovation activities in the past years.

## 1.2 National R&I strategy

The objectives of science and technology development in China are formulated by multi-annual plans, and the current main guiding policies for Science, Technology and Innovation include:

- The Medium- and Long-term National Plan for Science and Technology Development: 2006–2020;
- Made in China 2025;
- The 13th Five-Year Plan: 2016-2020

The Medium- and Long-term National Plan for Science and Technology Development: 2006–2020 (hereinafter MLP) was announced in February 2006. It sets the goal of building an innovative society by 2020 and indicates that innovation is a national strategy of China. The four main indicators used to assess progress and the corresponding target to be reached by 2020 are as follows: R&D as a percentage of GDP greater than 2.5%, comparing with EU's 3% target for R&D intensity; advances in S&T contributing at least 60% to economic growth; reliance on foreign technologies reduced to less than 30%; a rank among the global top five countries in terms of patenting and scientific publication citations.

Made in China 2025, which is announced in May, 2015, is the country's first action plan focusing on promoting manufacturing, designed to transform China into a world manufacturing powerhouse. The plan has set up three steps to realize the goal. The first step is to be accomplished by 2025, which is to significantly improve quality, innovation capacity, and labour productivity of the Chinese manufacturing industry. It will also reduce its energy and material consumption and pollutant emissions to be on par with the world's advanced level. The second step is to be accomplished by 2035, which is to elevate the Chinese manufacturing industry to the medium level of the first tier countries. In some sectors, Chinese companies will possess capability to be the global leaders. The third step is to be accomplished by 2050, when China's leadership in manufacturing will be consolidated and in major sectors and areas Chinese companies will become global leaders.

The 12 indicators which are used in "Made in China 2025" to monitor the progress are classified into four categories, namely innovation capability, quality, industrialization and informatization level and green development. Two indicators in the category innovation capability are the ratio of intramural R&D expenditure to primary business revenue and number of invention patents per primary business revenue of €12.25 Million (RMB 100 million). Three indicators fall into the category of quality, which include quality competitiveness index, value added rate and labour productivity growth rate. The indicators in the category of industrialization and informatization include broadband penetration, digitalized R&D tool penetration, and numerically controlled rate in key processes. The green development indicators include energy consumption per unit of value added, carbon dioxide emission per unit of value added, water consumption per unit of value added and re-utilization of industrial solid waste.

According to this plan, the following ten sectors have been identified as priorities for development and investment: new generation information technology, high-end numerically-controlled machine tools and robotics, aerospace equipment, marine engineering equipment and high-tech ships, advanced rail transportation equipment, energy-saving and new energy vehicles, power equipment, agricultural production machinery and equipment, new material, bio-medicine and high-performance medical devices.

The 13th Five-Year Plan (2016-2020) was announced in March, 2016, after it is approved in the Fourth Session of the $12^{th}$ National People's Congress. It is a comprehensive blueprint to guide China's economic and social development in the next five years. It is an overarching document listing the principles, measures, policies and even projects that China will implement to achieve the goals. This Five-Year Plan sets the goal of transforming China's economic growth pattern through technological innovation by 2020 and makes the proposals of strengthening the base and platform of science, technology and innovation. The plan has its second section titled with "implement innovation-driven development strategy", which includes five chapters. These chapters discusses the role of science and technology in promoting economic and social development, promotion of entrepreneurship and grass-root innovation, reform of S&T management system and incentivizing scientists and R&D staff to engage in innovation activities, human resource policy and the role of demand in promoting innovation.

The Plan stresses that China will continue to fund a few major R&D projects to develop core technologies in the strategically important areas, which include aircraft engine and gas turbine, deep ocean exploration, quantum communication and quantum computers, brain science, cyber security, space exploration and spacecraft in orbit maintenance. China will also invest in a few major engineering projects according to the Plan. They include seed breeding, clean coal technology, smart grid, information network, big data, smart manufacturing and robotics, new material, environment protection and reservation in the Beijing-Tianjin-Hebei area, and healthcare.

To summarize, the MLP is a strategy and policy document primarily focusing on S&T. Made in China 2025 is a strategy specifically for promoting the development of manufacturing industry. The 13$^{th}$ Five-Year Plan is however a comprehensive strategy for guiding the economic and social development of China in the period 2016-2020. It resembles the Europe 2020 strategy, which emphasizes smart growth through effective investment in education, sustainable growth through developing low-carbon economy and inclusive growth through job creation and poverty reduction. All these priorities in the Europe 2020 strategy are also included in the 13$^{th}$ Five-Year Plan of China. However, because the 13th Five-Year Plan contains 80 chapters which are clustered into 20 sections, such as implementing innovation-driven development strategy, advancing reform of institutional mechanisms, accelerating agricultural modernization, promoting balanced development, developing internet economy, improving the ecosystem, enhancing openness, improving social security and so on, it touches upon many more issues than Europe 2020 strategy.

## 1.3 R&I Policy initiatives, monitoring, evaluations, consultations, foresight exercises

China's research and innovation policies are instituted in a top-down manner, in which the central government frequently sets goals and objectives for S&T development. Investment in research follows a national strategy of building indigenous innovation capabilities and addressing societal challenges, reflected by priorities in energy, environment, agriculture, and healthcare. In 18th National Congress of the CPC held in November 2012, the Chinese leadership called for pursuing innovation-driven development strategy. It is envisioned that economic development in China would be driven more by domestic demand, especially consumer demand, by a modern service industry and strategic emerging industries, by scientific and technological progress, by a workforce of higher quality and innovation in management, by resource conservation and a circular economy, and by coordinated and mutually reinforcing urban-rural development and development between regions. In the third plenary Session of the 18th CPC Central Committee held in November 2013, the decision was made to deepen the comprehensive reform in the country in order to pursue the innovation-driven development strategy. Since the late 2013, several major policies and law amendments have been announced to accelerate the innovation-driven development strategy.

In December 2014, the State Council announced an **Action Plan on Implementation of the National Intellectual Property Strategy: 2014-2020**. It is a major policy document guiding the IP policy following the National Intellectual Property Strategy which was announced in 2008. The plan emphasizes that China plans to establish an efficient intellectual property system by 2020 that will substantially improve the creation, utilization, protection, management of intellectual property. The Action Plan puts forward four major actions to implement intellectual property strategy. The first is to promote the creation and utilization of IP to support the industrial transformation and upgrading. The second is to strengthen IP protection and create a favourable market environment. The third is to strengthen the IP management and improve management efficiency. The fourth is to expand international cooperation in IP and promote the improvement of international competitiveness. To achieve the major goals, the government will reinforce efforts to tackle infringement on intellectual property rights and create sound legal environment. Improved legislation and strict law enforcement are the necessary elements in the efforts. The government will participate in more joint enforcement efforts with international organizations and foreign governments. Moreover, a platform for trading intellectual property will also be established. The country will encourage investment in intellectual-property-intensive industries through market approaches such as private equity funds, and support them by boosting government purchases.

In January 2015, the Chinese government announced a **major reform on the S&T financing system**, which is to be finished by 2017. One of the objectives of the reform is to reduce the fragmentation and enhance the harmonization of the S&T funding system. The government will integrate more than 90 funding programmes managed by some 40 government departments into five major ones, which include the National Natural Science Foundation of China (NSFC), National Science and Technology Major Project, National R&D Key Programme, Technological Innovation Introductory Fund and Base and Talent Programme. The National Natural Science Foundation of China was established in 1986 with a mission to sponsor basic and applied research in natural science fields. It will be maintained in the new S&T financing system and continuously fund basic research and frontier research and support excellent scientists and their teams. The National S&T Major Project was established in 2006 after the announcement of the MLP. The objective of the Programme is to concentrate the resources on researching and developing some strategically important products and general-purpose technologies. Thirteen areas were selected as priorities to receive substantial funding.

Different from the NSFC and the National S&T Major project, the remaining three programmes are newly created. The National R&D Key Program will integrate many funding programmes previously managed by various ministries in the old system, for example, the 863 and 973 programmes. These two programmes will be eliminated in 2017. The Technological Innovation Introductory Fund will be used to support entrepreneurship, small- and medium-enterprises (SMEs) and incubators. The Base and Talent Program will support national key laboratories, national engineering centre and various talent programmes.

In the old system, each government agency managed its R&D programmes separately. Duplicate research may have been conducted due to a lack of communication and coordination between funding organizations. In the new S&T funding system, a joint committee will be established to oversee fund allocation, aiming to increase communication and coordination among government departments. The representatives of the ministries such as Ministry of Science and Technology, Ministry of Finance and National Development and Reform Commission will be members of the joint committee. The committee will make important decisions; including proposing call-for-proposal, selecting appropriate professional organizations to manage the projects, listing reviewers and terminating stalled projects. In addition, a strategic consultation and comprehensive review committee will be created, which is composed of representatives from science community, industry and economists. They will consult the joint committee regarding the trend of scientific research, industry development and strategy of S&T and innovation.

The second objective of the reform is to increase transparency and combat corruption. Under the old system, the government departments have the power to both distribute public research funds and supervise their use, which can easily lead to corruption. In the new system, government departments will not manage research projects. Instead, independent and professional organizations will be created to select the applications and manage the funded projects. The organizations will have to compete with each other to gain the service contracts offered by the government agencies.

Another important progress in R&I policy is the **amendment of the Law on Promoting the Transformation of Scientific and Technological Achievements** in August 2015. The original law was passed in 1996. The amendment 20 years after its passage aims to promote technology transfer from public research organizations and higher education institutions, incentivize R&D staff in the public research organizations and higher education institutions to start their own businesses and make innovations, and also create good policy environment for technology transfer. The new law clarifies IP ownership and decision-making authority over patens and technology, reduces legal risks associated with the transfer or sale of university-owned IP, and removes the policy impediments to university researchers' entrepreneurial start-ups and eventual public listing.

In terms of evaluations, National Centre for Science and Technology Evaluation is a department specialized in program evaluation, which is established in 2004 and affiliated with Ministry of Science and Technology. It employs more than 100 staff in-house and has connection with more than 5,000 external experts. It conducts evaluation in the following areas: evaluation of national strategies related to S&T (for example, the implementation of the tasks related to the S&T in the Five-Year Plans and the National IPR Strategy), national R&D programmes (such as National Science and Technology Major Project Program, 973 Program, 863 Program and National Natural Science Foundation etc.), S&T policies and regulation, budgets of national R&D programmes, performance of S&T institutions and so on. In some of the evaluations, for example, on the National Natural Science Foundation and the US-China Clean Energy Research Centre, the National Centre for Science and Technology Evaluation invites international experts to join the expert team.

The US-China Clean Energy Research Centre was established in 2011 as a result of the bilateral agreement of China and the US government on collaboration in clean energy area. The initial period of operation is five years. The National Centre for Science and Technology Evaluation conducted an evaluation on the US-China Clean Energy Research Centre during 2012-2013 (National Centre for Science and Technology Evaluation, 2016). Because of the positive outcome of the evaluation, both governments decided to continue to fund the Centre in the second five-year period (2016-2020) (Xinhua News Agency, 2015a).

Major R&D programmes in China publish annual reports which contain information about the budget, the funded projects and its management and operation. The quality of education and research in Chinese universities is generally carried out through a top-down monitoring by the Ministry of Education and its sub-national branches. For example, an influential evaluation of research universities by discipline is conducted by the Degree and Graduate Education Development Centre which is affiliated with the Ministry of Education. The evaluation was conducted three times so far, in 2004, 2009 and 2012 respectively. Evaluation criteria include the quality of faculty, quality of graduate education, quality of research and reputation of the graduates and so on.

The Ministry of Science and Technology, the Chinese Academy of Sciences and the Chinese Academy of Engineering conducts technology foresight periodically. Based on more than 100 experts' efforts, the Chinese Academy of Sciences published a series of technology foresight reports "Innovation 2050: Science, Technology and the Future of China" in 2009, covering 17 areas. The Planning and Development Department of the Ministry and Chinese Academy of Science and Technology for Development, a think tank affiliated with the Ministry conducted a technology foresight exercise in 2013.

## 1.4 Structure of the national research and innovation system and its governance

### 1.4.1 Main features of the R&I system

The Chinese research system is centralised and controlled by the central government in Beijing. The system is composed of three layers in an administrative hierarchical order: the top decision-making body, the policy formulation and implementation agencies, and the R&D performers (i.e. universities, research institutes, and business enterprises) (Figures 5 and 6 in Section 1.4.3). The Chinese research governance structure has a record of being effective in the implementation of national research and innovation strategies. Decisions related to S&T activities are made in the centre, and then go through the agencies and organisations in a hierarchical order (Li, 2012).

Regional governments (provinces, municipalities) in China are granted a high degree of autonomy for regulating and managing the local economy and society. The 1978 economic reform and subsequent arrangements ensured that the regional governments have sufficient capabilities and incentives to promote local economies. The motivation of economic development has been translated into the active roles of regional governments in making research policies and organising local R&D activities.

Provincial governments in China usually contain departments of science and technology, which are responsible for the S&T affairs in their purview. The provincial departments of science and technology also have R&D budgets and manage programmes to support R&D activities in the provinces. In some economically developed provinces, the S&T budgets are not trivial. Local governments' contribution on S&T was as half as that of the central government investment in R&D in 2014, and the ratio has increased from 39% in 2011 to 54% in 2014(China Statistical Yearbook, 2015).

Private sector funding in China accounted for more than two-thirds of total R&D expenditure, namely 78.2%, in 2014. In 2014, BERD amounted to 209.3 billion EUR, more than triple that of the public sector funding, namely 56.2 billion EUR. Public research organizations affiliated with government and universities are important players of the innovation system of China. The R&D performed by public research organizations and universities accounted for 15.8% and 6.9% of the GERD, respectively (See executive summary fact sheet).

National Basic Research Programme ("973 Programme"), National High-Tech Research and Development Programme ("863 Programme") and National Science and Technology Major Project are the major national R&D programmes. Each of the programmes has a distinctive emphasis, i.e. basic science, applied science and industrial technology. In addition to the abovementioned R&D programmes, the Torch Program which is managed by MOST, promotes high-tech industry and science park development. The Spark Program, also managed by MOST, focus on development and dissemination of agricultural technologies.

### 1.4.2 Governance

The National Steering Committee for S&T and Education in the State Council was established in 1998 and has been the highest decision-making body in the research system. The chairman of the Committee is the Premier and the members include the ministers of NDRC, MOST, Ministry of Education, Ministry of Finance and other ministries. It has been in charge of strategic goal-setting, medium- and long-term planning, and occasionally, initiating reforms of the research system. However, the Committee has not held a meeting since the late 2013, because it has been superseded by the Leading Group for Overall Reform, which was established after the Third Plenary Session of the 18th CPC Central Committee held in November 2013. President Xi Jingping heads the group as the chairman and Premier Li Keqiang, member of the secretariat of the CPC Central Committee Liu Yunshan and Vice Premier Zhang Gaoli act as the deputy chairmen. The Leading Group is in charge of designing, coordinating, pushing forward and supervising the implementation of the reform plans, including the ones in science, technology, education area.

On the policy layer, the Ministry of Science and Technology is the main government body that formulates S&T policy, makes short-term planning, and funds national R&D programmes. Being the economic and industry policy maker, the National Development and Reform Commission and Ministry of Industry and Information Technology (MIIT) are also involved in innovation policies; particularly those related to industry, as well as funding R&D and industrial application. Certain sectorial innovation policies are made in the Ministry of Agriculture and National Health and Family Planning Commission and so on. In terms of research funding, the National Natural Science Foundation of China is a major player in addition to MOST, NDRC and MIIT. Within the public research system, the Chinese Academy of Sciences (CAS) is the leading institute. CAS also plays a leading role in S&T policy advice and the regulation of public research organisations.

### 1.4.3 Research performers

The Chinese research and innovation system before the S&T financing system reform was launched in 2015 is described in Figure 5. High-level Leading Group for Overall Reform which is headed by President Xi Jingping is responsible for designing the top-level strategies. Various ministries and sub-ministry departments manage R&D programmes which fund basic research, applied research and development activities. Chinese Academy of Sciences and other public research organizations, universities and enterprises compete for funding from the programmes.

After the S&T financing system reform concludes in 2017, the future research system in China will look as shown in Figure 6. In the future system, the Leading Group for Overall Reform is still the top-level strategy-making body. However, the ministries will not directly manage R&D programmes. Instead, their representatives will participate in a joint committee and receive consultation from a strategic consultation and comprehensive review committee. The ministries can coordinate and communicate with regard to funding through the committee. The joint committee will select independent and professionals institutes to manage the R&D programmes. The more than 90 R&D programmes managed by some 40 government agencies will be consolidated into five programmes. Among them, National Natural Science Foundation and National Science and Technology Major Project Program were already created before the reform. The National R&D Key Program, Technological Innovation Introductory Fun and Base and Talent Program are newly created programmes (Their missions are documented in Section 1.3).

**Figure 5** – Overview of China's Research System Governance structure - before 2017

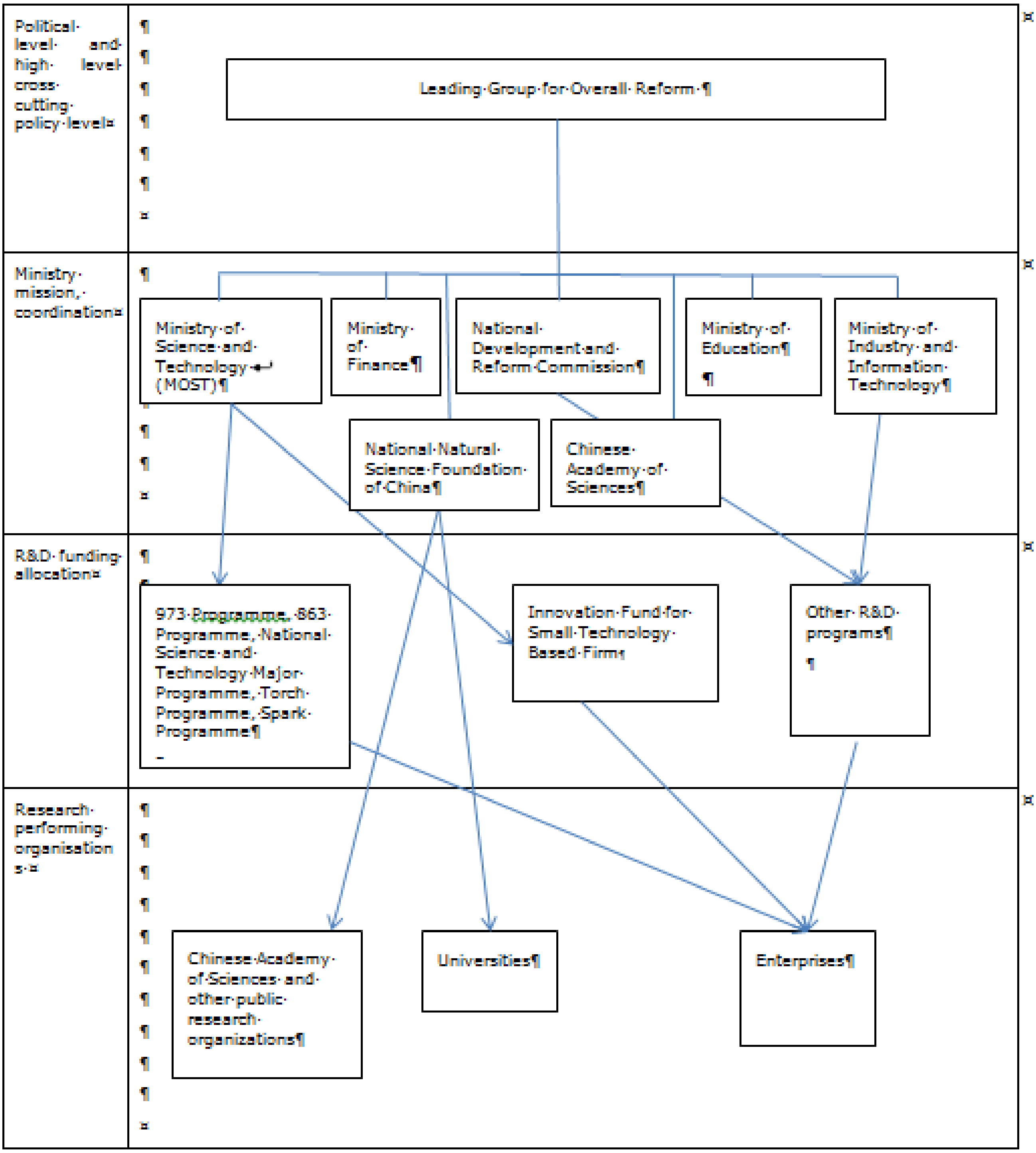
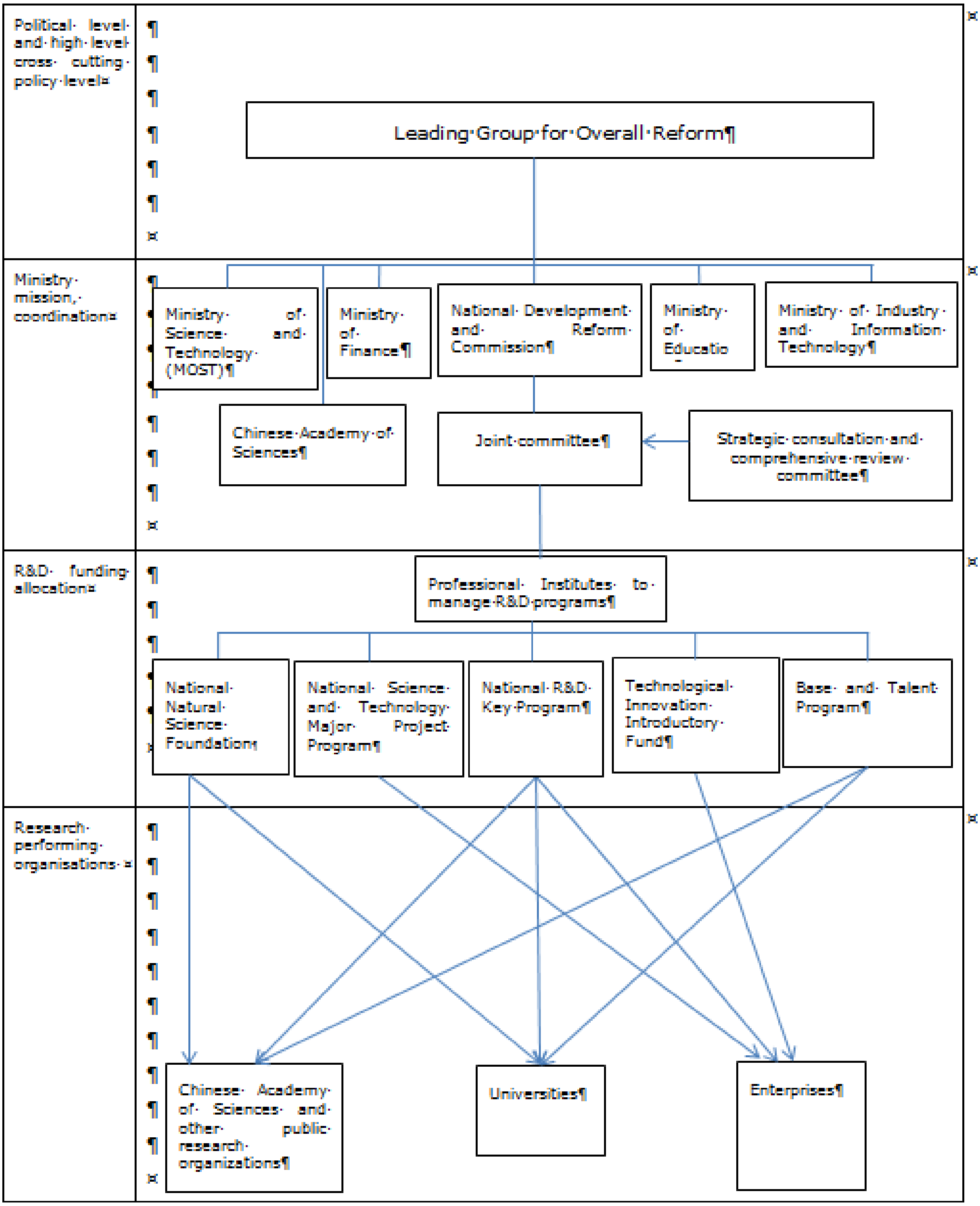


**Figure 6**– Overview of China's Research System Governance structure - after 2017



## 1.5 Quality of the science base

**Table 8** – Performance of the R&D System in China and EU

| **Indicator** | **China** | **EU average** |
|---|---|---|
| Number of publications per thousand of population | 0.35 (2013) | 1.43 |
| Share of international co-publications | 15.4% (2013) | 36.4% |
| Number of international publications per thousand of population | 0.05 (2013) | 0.52 |
| Percentage of publications in the top 10% most cited publications | 7.4 (2010) | 10.55 |
| Share of public-private co-publications | 1.0% (2011-2013) | 1.8% |

As seen in Table 8, in almost all indicators which are normalized by population size, China lagged behind the EU-average. However, the quality of the Chinese R&D system has steadily increased in the past years. The innovation system and policy in China has transformed in the following ways which give incentives to production of high-quality research. First of all, R&D funding allocated by national R&D programmes is mostly competitive rather than institutional. The competitive funding system gives pressure and incentive to researchers to produce high-quality research. Second, the Chinese governments at various levels established human resource programmes to attract overseas students and scholars to come back to China, such as "1000 Talent" Program set up by the Organization Department of CPC. The returnees who had training and working experience in the overseas leading institutions are expected to produce high-quality research. Third, the policy enacted by the governments and regulations in public research organizations and higher education institutions encourage Chinese scientists to engage in international collaboration. For example, there is a funding theme in the National Natural Science Foundation that is specifically for international collaboration. Research has demonstrated that the publications co-written by Chinese scientists and foreign collaborators have higher impact than the publications only written by Chinese scholars (Tyfield et al., 2009).

## 1.6 Main policy changes in the last five years

**Table 9** - Timeline of policy changes related to STI (2011 - 2015)

**Main Changes in 2011**

A full proposal for the **12th Five-Year Plan** was released and approved by the National People's Congress on March 14, 2011, with the goals of addressing rising inequality and creating an environment for more sustainable growth by prioritizing more equitable wealth distribution, increased domestic consumption, and improved social infrastructure and social safety nets.

**Main changes in 2012**

On July 9, 2012, to accelerate the incubation and development of the country's strategic emerging industries (SEIs), China's State Council issued the "**12th Five-Year Development Plan for National Strategic Emerging Industries**". The plan lays out 7 strategic emerging industries and 20 key projects.

On September 23, 2012, the CPC Central Committee and the State Council issued the "**Opinions on Deepening the Reform of the Scientific and Technological System and Speeding up the Building of a National Innovation System**".

**Main changes in 2013**

In March 2013 the 12th National People's Congress outlined the strategic document "**Further reform of the S&T system and build enterprise-centred innovation system**," released by the State Council in 2012. China's new Leadership emphasized reforming the S&T system to strengthen "Industry-University-Research" linkages, and cultivate research and innovation capacity in the business enterprise sector.

As part of the New Leadership's anti-corruption campaign in early 2013, Ministry of Science and Technology tightened the **monitoring of S&T funding usage** in national-funded research projects.

In May 2013, the **National Technology Innovation Project Coordination Group** was established to coordinate innovation-related S&T, industrial, tax and financial policies among 15 ministries, including NDRC, MOST, and Ministry of Finance and the National Development Bank.

**Main Changes in 2014**

In March 2014, the **State Council issued documents on the reform of fund management for S&T Programmes**, aiming at reforming the management system of S&T programmes funded by the central government budget, building up a national S&T Reporting System, and reforming the management system of scientific research achievements.

**Main Changes in 2015**

The State Council issued "**Made in China 2025**" plan on May 19, 2015, the country's first ten-year action plan focusing on promoting manufacturing. Nine tasks have been identified as priorities, including improving manufacturing innovation.

On October 1, the **Law on Promotion of Transformation of Science and Technology Achievements** came into effect, after having been passed by the NPC on August 29, 2015. The new law is expected to facilitate technology transfer from universities and research institutions to industry.

# 2. Public and private funding of R&I and expenditure

## 2.1 Introduction

The Gross Expenditure on R&D (GERD) as percentage of GDP in China increased steadily from 1.79% in 2011 to 2.05% in 2014, which reflects the continued grow of R&D intensity in the Chinese economy (Table 10). However, as China is still considered a developing country with a large population, the GERD per capita of China is still at 20% level of the EU average in 2014.

China performs well in comparison to the EU average in terms of the share of Business Expenditure on R&D (BERD) and the percentage of R&D funded by the Business Enterprise Sector (BES). Table 10 shows that R&D funded by BES as a percentage of GDP and R&D performed by BES as a percentage of GDP in China are both higher than those of the EU average in 2014. In addition, both percentages increased from 2011 to 2014. This demonstrates the importance role that the BES plays in the Chinese innovation system.

Public investment in R&D in China also plays a significant role in reaching the national R&D targets. The absolute volume of Government Budget or Outlays on R&D (GBOARD) in China increased from 20,919 million Euros in 2011 to 32,285 million Euros in 2014, representing a 50% increase within four years. However, the 2014 volume is still as much as one third of the volume of the EU average. However, as the Chinese economy also grew fast during the same period, the GBOARD as percentage of the GDP hovered around 0.4 percent, falling short of the EU average 0.67 percent. The central government S&T appropriations accounts for around 4% of the central government budget since 2011. However, the percentage has been dropping from 4.4% in 2011 to 3.5% in 2014. The share of local government S&T appropriations in total local government budget was increased slightly from 2.0% in 2011 to 2.2% in 2014. In 2014, the central government invested 65 billion Euros (RMB 531 billion), or 3.5% of the total government budget, in S&T development. Local governments' contribution on S&T was as half that of the central government investment in R&D.

In terms of the distribution of R&D performed by Higher Education Institutions (HEIs), Government Sector (GOV) and Business Enterprise Sector (BES), the importance of Business Enterprise Sector in the Chinese innovation system has been strengthened in the period of 2011 to 2014, as demonstrated by the growing percentage of R&D either being funded or performed by the Business Enterprise Sector (BES).

**Table 10–** Basic indicators for R&D investments

| **Indicator** | **2011** | **2012** | **2013** | **2014** | **EU average 2013** |
|---|---|---|---|---|---|
| GERD (as % of GDP)[1] | 1.79 | 1.93 | 2.01 | 2.05 | 2.03p(2014)<br>2.03 (2013) |
| GERD (Euro per capita)[2] | 130 | 165 | 181 | 199 | 558.4p (2014)<br>542 (2013) |
| GBAORD (€m)[3] | 20,919.33 | 27,401.90 | 30,413.65 | 32,284.72 | 92,828.145 (2014) |
| GBOARD as %of GDP[4] | 0.39 | 0.42 | 0.43 | 0.41 | 0.67 (2014) |
| R&D funded by GOV and HEIs (% of GDP)[5] | 0.39 | 0.42 | 0.43 | 0.41 | 0.68 |
| R&D funded by PNP (% of GDP) | N/A | N/A | N/A | N/A | 0.03 |
| R&D funded by BES (% of GDP)[6] | 1.33 | 1.43 | 1.50 | 1.54 | 1.12 |
| R&D funded from abroad (% of GDP)[7] | 0.024 | 0.019 | 0.018 | 0.017 | 0.2 |
| R&D performed by HEIs (% of GDP)[8] | 0.14 | 0.15 | 0.15 | 0.14 | 0.48 |
| R&D performed by GOV (% of GDP)[9] | 0.29 | 0.31 | 0.33 | 0.32 | 0.25 |
| R&D performed by BES (% of GDP)[10] | 1.36 | 1.47 | 1.54 | 1.58 | 1.29 |

Source: Data for the indicators with superscript 1, 2, 5, 6, 7, 8, 9 and 10 are from OECD (2015), and for the indicators with superscript 3 and 4 are from National Bureau of Statistics of China (2016)

Note: 1.The data represent the R&D performed by the enterprises above the designated scale, that is, the revenue of the enterprises greater than RMB 20 million (€2.45 million).

## 2.2 Funding flows

### 2.2.1 Research funders

It was announced in January 2015 that China will undertake a major reform of its S&T funding system, which is a part of the systematic economic and administrative reform in China unveiled in the Third Session of the 18th CPC Central Committee held in November

2013. In the old S&T funding system which has been in place nearly three decades, the major funding agencies in China are the National Natural Science Foundation of China (NSFC), the Ministry of Science and Technology (MOST), Ministry of Education, National Development and Reform Commission (NDRC), Ministry of Agriculture, Ministry of Industry and Information Technology (MIIT), and other government agencies. These agencies oversee the S&T fund allocated from the central government's budget, which in total amounts to €30.6 billion (RMB 250 billion) every year.

Among the funding programmes overseen by the Ministry of Science and Technology, the National Basic Research Programme ("973 Programme"), the National High-Tech Research and Development Programme ("863 Programme") and the National S&T Major Projects are the major R&D programmes. Each of the programmes has a distinctive emphasis. For example, the 973 Programme focuses on basic science and the 863 Program funds mainly the applied science and industrial technology in high-technology area.

In the future S&T funding system, some 90 competitive grant schemes run by 40 different government departments will be integrated into five major programmes, which include the National Natural Science Foundation of China, National Science and Technology Major Project, National R&D Key Program, Technological Innovation Introductory Fund and Base and Talent Program. The National S&T Major Project will be managed directly by the State Council. The National R&D Key Program will be the successor of the many funding programmes managed by various ministries before. For example, the 863 and 973 programmes will be eliminated by 2017. The Technological Innovation Introductory Fund will be used to support entrepreneurship, SMEs and incubators. The Base and Talent Program will support national key laboratories, national engineering centre and various talent programmes. Independent institutes will be created to manage the application and selection of the applications to the five programmes. The reform allows a transition spanning from 2015 to 2017. The detail of this reform can be found in Section 1.3.

### 2.2.2 Funding sources and funding flows

In China, the central government is an important funder for R&D activities. In 2014, the central government invested 65 billion Euros (531 billion RMB), or 3.5% of the total central government budget, in S&T development. The local governments invested 35 billion Euros (288 billion RMB), or 2.2% of the total local governments' budget in S&T activities. Local governments' contribution on S&T was half that of the central government investment in R&D in 2014, but the ratio has increased from 39% in 2011 to 54% in 2014. (National Audit Office of China, 2015) International funding has been small in China. For example, in 2013, the R&D funded from abroad only accounted for 0.02% of China's GDP, in comparison to 0.2% in Europe (Table 10).

Among the total GERD of China, namely € 277.6 billion in 2014, the public sector spent €56.2 billion (20.9%) and the private sector spent €209.3 billion (78.2%). Among the expenditure by public sector, €42.2 billion was spent by public research organizations and higher education institutions, and €9 billion was spent by business enterprises. Among the expenditure by private sector, €12.2 billion was spent by public research organizations and higher education institutions, and €201.1 billion was spent by business enterprises (OECD, 2015). The breakdown of the GERD by source of funding and sector of performance can be found in the fact sheet in the executive summary.

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## 2.3 Public funding for public R&I

Funding mechanisms for national R&D programmes are mostly competitive rather than institutional. Some of the competitive programmes (i.e. the fund allocated by the National Natural Science Foundation of China, 973 Program, 863 Program and so on), require a local match from the applicant (business enterprise or public research organisation) and the sub-national government. But there are special schemes of block funding for targeted institutes or researchers. For example, the 985 Programme ("World Class Universities") provided block funding to a group of elite 39 higher education institutions with the mission to become world-class universities. The 211 Program ("High-level Universities and Key Disciplinary Fields" Program) provided block funding to a group of 112 key universities which including the 39 universities funded by the 985 Program. These two programmes supporting universities were run with a partnership between the central government (Ministry of Education and other ministries with their own universities) and local governments which matched the central government funding. In the grants themselves, the 985 and 211 programmes do not cover salary costs of researchers unlike most European schemes.

For prioritised areas in MLP, China also established mission-oriented National S&T Major Projects. Currently there are thirteen active mega projects, supporting R&D in technologies such as general purpose computer chip, wireless communication, high-precision machine tools, nuclear power, and HIV/AIDS treatment and so on. The Major Projects operate on their own budgets as well as providing an umbrella scheme pooling funds from other national programmes.

Many of the R&D programmes evaluate the applications based on peer review results. For example, the National Natural Science Foundation of China with an annual budget € 3,062 million (RMB 25 billion) in 2014 funded 39,089 projects (National Natural Science Foundation of China, 2015). The average success rate is 25%. Most of the projects funded by the NSFC can be considered as individual grants. For instance, the NSFC funded 16,421 youth projects applied for by young scientists below age 35 in 2014. It also funded 107 foreign young scholars through its Fund for International Young Scientists with annual calls. The Fund supports foreign young scientists to conduct basic research in mainland China in all areas of science, engineering and health research with the aim to promote academic collaboration and exchanges between Chinese and foreign young scientists.

## 2.4 Public funding for private R&I

### 2.4.1 Direct funding for private R&I

The Chinese government encourages private firms to apply for public funding for R&D. The Innovation Fund for Small Technology-based Firms (InnoFund) set up by the Ministry of Science and Technology in 1999 is an example of public funding programme to support R&D in private sector. The fund provides financial support to small technology firms through grant, loan interest subsidy and equity investment. It has a mission of facilitating and encouraging innovation activities of small technology-based firms and promoting technology transfer through financing. It also works to bring along private investment so as to promote the establishment of technology-based firms. The latest available annual report of the InnoFund shows that in 2013 the Fund financed 6,446 new projects with total budget of €622.7 million (RMB 5.12 billion). On average each project received funding of €96 thousand (RMB 790 thousand). From 1999 till 2013, the total investment by the central government to the Fund amounted to €3,286 million (RMB 26.83 billion). The total number of projected supported during the 1999-2013 period amounted to 46,282. The projects financed by the InnoFund are usually co-financed by the local governments, banks and the companies themselves. For example, in 2013, the total budgets of the on-going projects financed by the InnoFund amounted to €3,690 million (RMB 30.34 billion), among which €328.4 million (RMB 2.70 billion) was invested by the InnoFund, €98.5 million (RMB 0.81 billion) was invested by local governments, €

386.8 million (RMB 3.18 billion) by banks, €2,457 million (RMB 20.20 billion) by the companies themselves, and €420.8 million (RMB 3.46 billion) through other means. In this sense, the InnoFund leveraged the resources in the possession of local governments and financial institutions to support the high-tech SMEs' development (InnoFund, 2014). There are other similar but smaller programs run by provincial governments. However, these programs are less well known and were not run for a long period of time.

### 2.4.2 Indirect financial support for private R&I

China enacted a tax incentive policy to spur R&D as early as 1996 (Wang, 2009). However, at that time, the enterprises which are eligible to tax incentive policy were limited to the state-owned or collective owned enterprise. Starting from 2003, companies of all ownership were eligible. In addition, the regulation was streamlined in the past years to make it easier companies to use the policy. For example, before 2004, the tax bureau has to approve the tax deduction. From 2004, companies can apply for deduction voluntarily without approval of the tax bureau. In addition, the scope of R&D expenditure was expanded several times. A recent example is the decree No.[2013]70 which came into effect in 2013. The scope of the R&D expenditure to be deducted from taxable revenue started to include the health insurance and salary of the R&D staff and cost of clinical trial of new drug. In the decree No.[2015]119, the scope of the tax incentive was further expanded. For example, in the decree No.[2008]116, only the companies operating in the industries listed as the "High-technology Priority Industries" by NDRC and other government agencies can enjoy the tax incentive. These industries included ICT, biotechnology and pharmaceuticals, aerospace, new material, high-tech service, new energy and energy-saving, environmental protection technologies and so on. In the decree No.[2015]119, all the industries are included except for tobacco, hotel and restaurant, wholesale and retail, real estate, leasing and business service, entertainment sectors. This dramatically enlarges the industries which are eligible for the R&D tax relief policy. The 2015 decree also expanded the scope of the eligible R&D activities and R&D expenditure, and simplified the certification process of the R&D projects and reduce the administrative burden of the companies which apply for the tax relief.

Effective from January 2008, the amended Enterprise Income Tax Law offers high-tech and new-tech enterprises a reduced corporate income tax rate (which is 15% instead of 25% for non-high-tech firms) and a tax break of "2-year tax exemption and 3-year 50% deduction" if located in the prescribed areas (i.e. Science Parks). In addition, indirect tax incentives are offered, such as business tax exemption and duty-free import of equipment and spare parts.

Another important policy measure to support for private R&I is high-tech zones. High-tech zones were established at national level, provincial and municipal levels, supported by the central, provincial and municipal governments, respectively. The benefits that the companies can receive varied in different zones depending on by which levels of governments the zones were supported. Local government may provide additional support in addition to the favourable policy enacted by the central government. At the national level, there are 115 national high-tech zones across the countries. 74,275 companies operated in these zones and employed 15 million staff in 2014. The total revenue of the companies in the zones amounted to 22.7 trillion RMB in 2014 (€ 2.8 trillion) (National Bureau of Statistics, 2016). The national high-tech zones were managed by the Torch Programme (Torch High Technology Industry Development Centre), which was established in 1989 by the Ministry of Science and Technology.

## 2.5 Assessment

In the past five years, as the Chinese economy continued to grow, so has the public R&D funding invested by various levels of governments. The sum of S&T expenditures by the central government and local governments increased from €74.25 billion (RMB 66.8 billion RMB) in 2011 to €100.33 billion (RMB 81.9 billion) in 2014, representing a 20 percent increase over the four years (China Statistical Yearbook, 2015). Most of the R&D

funding is allocated based on competitive project funding. According to the Reform of Fund Management for S&T Programmes (the State Council, 2014a) and the Regulation on the National Natural Science Foundation of China (the State Council, 2007), R&D grants from the central government (including the National Natural Science Foundation of China) shall be awarded based on the principle of fair competition. Based on the guiding principles from the Central Government, local governments establish similar application rules. Quality instead of quantity is emphasized during the funding allocation. Supported by the increasing financial support, the R&D output as measured by scientific publications and patent applications in China also grew rapidly.

Although the scale of public R&D funding increased, the weaknesses of the system became salient. A major one is the fragmentation of the system. The first public R&D funding program was established during the period of 1981-1985. Along the years, Spark Program, the National Natural Science Foundation of China, the 863 Program, Torch Program, the 973 Program and some other 90 funding schemes were established. Because these programmes were set up in different periods and are managed by more than 40 governmental agencies, they lack of coordination. Limited public funds were spread too thin in the system. The reform plan announced in January 2015 to be implemented from 2015 to 2017 aims to overcome the fragmentation of the system, by integrating the various funding programmes into five major ones, as documented in the Section 2.1.

Another weakness of the current public S&T funding system was that the government agencies are responsible for the whole process of fund allocation, from call-for-proposal, receiving and evaluating application, to managing the funded projects. Because all the power is concentrated in the government, when there is lack of supervision and transparency, it can easily give rise to corruption and abuse. To tackle this challenge, the central government will appoint specialized organizations to select applications and manage the funded projects and the government agencies will not manage projects any more. These specialized organizations will report to the Joint Committee of the National Public R&D funding and sign contract with the government agencies. They will operate according to a high standard of efficiency and integrity (MOST, 2016).

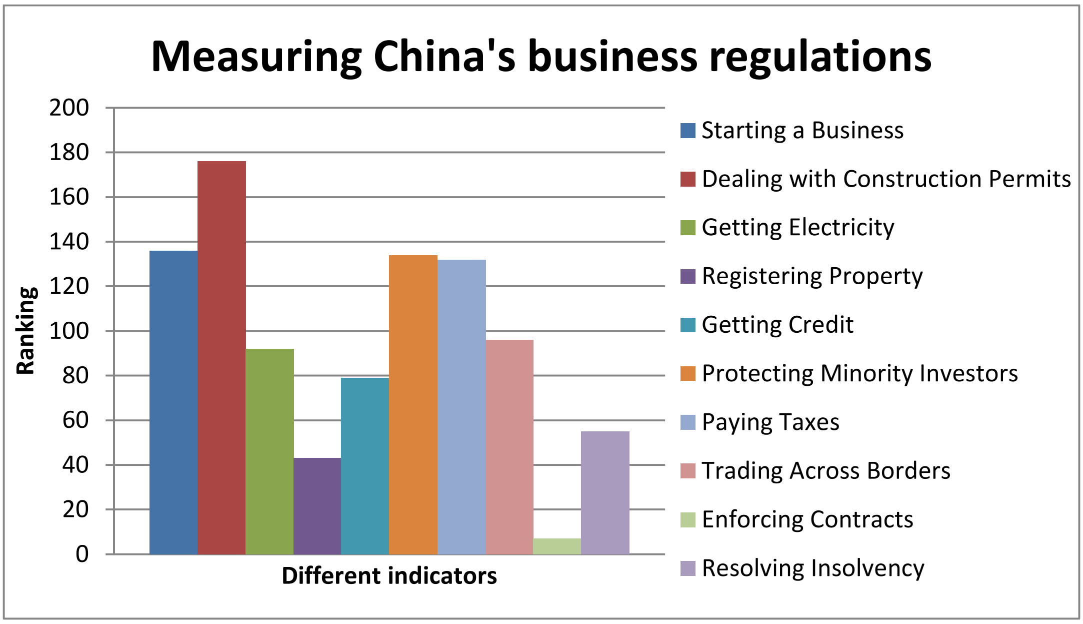
# 3. Framework conditions for R&I

## 3.1 General policy environment for business

China officially joined the World Trade Organisation (WTO) in November 2001. Under the WTO, tariffs on agreed products have been reduced, and market access to various regulated industries has been phased in gradually.

The World Bank "Ease of doing business index" provides objective measures of business regulations and their enforcement across 189 economies. A high ranking of an economy (a low numerical rank) means that the regulatory environment is conducive to business operation (1=most business-friendly regulations). China is placed 84th in the rankings for all economies benchmarked to June 2015, which implies China's general business regulation environment is friendlier than world's average. Detailed measurements of specific aspects are provided in figure 7 below.

**Figure 7**– Measuring China's Business Regulations




Source: World Bank(2015)

In terms of starting a business, China's low ranking indicates the difficulty for start-ups to enter the economy. However, the new Chinese administration headed by Premier Keqiang Li, who swore in office in March 2013, has been making serious efforts to curb the power of bureaucrats. One of the important actions is to streamline and simplify the process of business registration. The number of newly registered businesses in 2014 increased by 46% compared with the number in 2013 (Xinhua News Agency, 2015b). The number in 2015 increased by 15% compared with that in 2014 (Chinese Economy Web, 2016). It is expected that China's rank in terms of difficulty of starting a business will be improved in the next years. However, China is ranked 180$^{th}$ worldwide for dealing with construction permits, which is almost the hardest in the world. Regulations on protecting minority investors paying taxes are also considerably weak in China. In terms of ease of registering property and resolving insolvency, China ranks relatively higher, around 40$^{th}$ to 60$^{th}$. In terms of ease of enforcing contracts, China ranks 7th among all countries.

## 3.2 Young innovative companies and start-ups

As the economic growth in China slowed down since 2012, the Chinese government believes that the power of "mass entrepreneurship and innovation" will ensure the Chinese economy can avoid a hard landing. In November, 2014, the State Council issued "Opinions of the State Council on Supporting the Sound Development of Micro and Small

Enterprises”. In the Opinion, favourable policies in terms of tax deduction for micro and small enterprises are announced. Micro and small enterprises investing in projects which are encouraged by the state or importing advanced equipment unable to be produced domestically for self-use shall be exempted from customs duties (State Council, 2014b). In addition, special funds will be available for supporting the building of small enterprises entrepreneur bases (micro enterprise incubators, technology incubators, commercial enterprise clusters, and so on). Besides, it is required that 4000 public service platforms serving small-and-micro sized enterprises shall be established and improved and 500 national public service platforms for small-and-medium sized enterprises are to be established by the end of 2015.

In June 2015, China’s State Council issued guidelines on specific measures to boost mass entrepreneurship and innovation. Firstly, governments at any level are innovating their institutional mechanisms to optimize financial policies to support mass entrepreneurship and innovation. Strengthened financial support policies, inclusive funding measures (including expanding access to affordable financial services for all individuals and businesses, especially to low income households, rural residents and SMEs) and more government procurement exclusively open to SMEs will be seen in the near future.

Meanwhile, the Chinese government encourages corporations to raise funds through the bond market, and will explore practical ways to enable start-up Internet and high-tech companies to enter specialized stock exchanges under the growth enterprise market (GEM) category. The Growth Enterprise Market was originally designed to accommodate vigorous scientific and technological innovation and the boom of start-ups around the world in the 1970’s (Zhou, 2009). It was launched in October, 2009 in mainland China as the second board of China stock market after a decade of preparation. Moreover, Shanghai stock exchange explored to establish a strategic emerging industries board, which specifically supports development of the strategic emerging industries (State Council, 2015a). Banks are also required to cooperate with other financial institutions such as securities firms, insurance firms, financial leasing corporations and guarantee corporations to strengthen their services for start-up firms, offering targeted financial products and more professional services (State Council, 2015a).

The government will also establish a mechanism to guide investment to entrepreneurs and expand channels for entrepreneurs to raise funds. It will also encourage State-owned enterprises to invest on start-up companies, and boost investment on both domestic and international innovative projects. To help scale up small and micro firms, the government issued a plan to support the healthy development of small and micro enterprises in 2014 (State Council, 2014b). The plan covers a broad range of measures from establishment of public service platforms to subsidizing small and micro companies’ social security expense.

The State Council issued a circular in September 2015, to support the ongoing reform of mass entrepreneurship and innovation and the Internet Plus initiative with four measures, including joint support for small and micro businesses and start-ups. According to the circular, universities and scientific research institutions are encouraged to open scientific research facilities for small and micro businesses and start-ups, and large and medium enterprises will be encouraged to support them by establishing open platforms and sharing resources (Yuan, 2015). On the other hand, the government motivates large companies to invest in or acquire small and micro firms, in which way they can realize upgrading and transforming and also provide an exit path for investors of start-ups (Yuan, 2015). In addition, open-source communities, developer communities, resource-sharing platforms, donating platforms and entrepreneurship salons will be encouraged to build up mass support for entrepreneurship and innovation.

Besides the above supporting measures, the Chinese government also aims to address the issue of supply of entrepreneurs. In May, 2015, the State Council announced “Opinion on Deepening the Reform of Innovation and Entrepreneurship Education in

Colleges and Universities", to cultivate more young talents with entrepreneurial training. According to the Opinion, Chinese universities should strengthen education in innovation and entrepreneurship, by setting up related majors and courses and providing comprehensive and effective guidance on entrepreneurship. Universities are also encouraged to build up practical training platform, making full use of various resources such as universities' science park, which providing students with learning-by-doing opportunities (State Council, 2015b).

In addition, stated-owned–enterprises (SOEs) are also required to get involved in mass innovation and entrepreneurship. In September, 2015, Premier Keqiang Li announced in the symposium on deepening transformation and development of SOEs, that mass innovation and entrepreneurship is not only the way for individuals and start-ups to grow bigger, but also can bring vigour to SOEs. Following the "Internet Plus Initiative", SoEs can create platforms for crowd innovation and crowd outsourcing, and crow funding to combine the power of individual employees and the whole society, by which innovation capability of SOEs gets enhanced. In addition, by promoting entrepreneurship, and enlarging entrepreneurial team, SOEs are expected to achieve more improvements during the reform (Xinhua News Agency, 2015c).

Through these efforts, some industrial sectors have shown very impressive performance in terms of entrepreneurial activities, such as internet and high-tech industries, which require customer-focused innovation. Based on large size of Chinese consumer market, appliance makers such as Haier and telecommunications equipment manufacturers such as Huawei, and internet companies including Baidu, Alibaba, and Tencent now become global leaders in their respective areas. Six-year-old Xiaomi, a Beijing-based smartphone maker, has become one of the world's most successful start-ups. Business model innovations of Xiaomi such as online-only sales and risk sharing with suppliers lead to a surprisingly low price of its launched products, yet provide comparable or better hardware features (Mckinsey, 2015). Moreover, it has also cultivated user pride through user-cantered and open innovation, continually attracting enthusiastic and loyal customers known as Mi-Fans (Dong and Zhang, 2015).

## 3.3 Knowledge transfer and open innovation

China promulgated the law of technology transfer in 1985. The law stipulates that technology transactions are exempt from value-added tax as long as the contracts are verified by provincial bureaus of science and technology. Approved contracts are registered in the so-called technology market in provincial governments. These contracts can be classified into several categories: commissioned technology development, technology transfer, consultancy, and service. The volume of university technology transfer contracts in China accounted for 20.5% of the national total, which demonstrates the importance of universities in the landscape of technology transfer and academia-industry collaboration. However, the value of these contracts was 4.6% of the national total (see Tables 11 and 12), showing that the technology transfer with large value happened more often between enterprises than between universities and companies.

**Table 11**– Volume of University Technology Transfers, 2011-2015

| | Invention patents licensed | | Technology transfer contracts | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Ministry of Science and Technology | | Ministry of Science and Technology & Innofund | | Ministry of Education | | | |
| **Year** | Volume (10,000 patents) | % National | Volume (10,000 items) | % National | % State-owned contracts | % Foreign-owned contracts | % Private contracts | % Other contracts |
| **2011** | 2.5 | 47.2 | 5.0 | 19.4 | 33.3 | 4.9 | 51.3 | 10.5 |
| **2012** | 3.4 | 43.6 | 5.8 | 20.5 | 34.3 | 4.6 | 51.9 | 9.2 |
| **2013** | 3.3 | N.A. | 6.4 | 21.8 | 30.5 | 4.1 | 53.2 | 12.2 |
| **2014** | 3.8 | N.A. | 5.4 | 18.3 | N.A. | N.A. | N.A. | N.A. |

Sources: Innofund Annual Report on Statistics of China Technology Market (Innofund 2004-14), SIPO Patent Statistics Summary Report (SIPO 2012a), MOST S&T Statistical Reports (MOST 2008-13), and MOE DOST Statistical Reports (DOST 2007-13)

**Table 12** – Value of University Technology Transfers, 2011-2015

| | Ministry of Science and Technology & Innofund | | | | Ministry of Education | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | Total revenue (CNY 100 million) | % National | Avg. revenue per contract (CNY 100 million) | % National | % State-owned contracts | % Foreign-owned contracts | % Private contracts | % Other contracts |
| **2011** | 248.8 | 5.2 | 50.0 | 27.0 | 34.1 | 6.0 | 45.9 | 14.0 |
| **2012** | 294.0 | 4.6 | 50.7 | 22.2 | 38.4 | 5.2 | 45.6 | 10.8 |
| **2013** | 329.5 | 4.4 | 51.2 | 20.2 | 37.2 | 5.8 | 42.1 | 14.9 |
| **2014** | 315.1 | 3.7 | 58.0 | N.A. | N.A. | N.A. | N.A. | N.A. |

Sources: Innofund Annual Report on Statistics of China Technology Market (Innofund 2004-14), SIPO Patent Statistics Summary Report (SIPO 2012a), MOST S&T Statistical Reports (MOST 2008-13), and MOE DOST Statistical Reports (DOST 2007-13)

Since the late 1980s, the policies in China have always encouraged spin-offs from universities, which are considered an effective way of technology transfer. The number of university-run enterprises reached about 2000, with 238,000 employees, among which 78,000 are scientific researchers. Their total sales income increased from €226.6 billion to €553.6 billion (RMB 18.5 trillion to 45.2 trillion) (World Intellectual Property Organization, 2007). According to World Bank's 2001 report on "China and the Knowledge Economy", in 2001 Beijing University and Tsinghua University had already created about 60 spin-offs each. A significant proportion of their revenue derived from spin-offs' profits.

In order to encourage university technology transfer, the Chinese government established university science parks. The Ministry of Science and Technology and Ministry of Education issued a National University Science Park Development Plan in August, 2011. The amended Law on Promoting the Transformation of Scientific and Technological Achievements also emphasizes that the state shall support the development of institutions for incubation of science and technology enterprises, providing spaces, business counselling, R&D management consulting, and other services to small- and medium-sized scientific and technological enterprises at the start-up stage.

By the end of 2014, there were 115 national university science parks in China (Table 13). For example, a large science park is established by Tsinghua University in the Zhongguancun high-technology zone. The science park includes an incubator that has hosted more than 400 high-tech companies, some of which are already listed on the stock exchange.

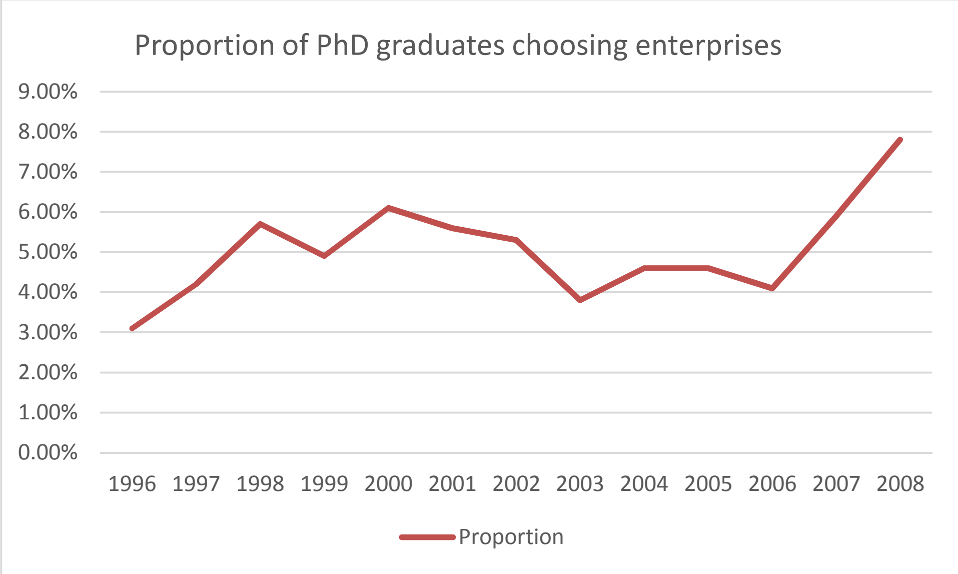
**Table 13**– Main Economic Indicators of National University Science Parks

| Year | Number of University Science Parks(unit) | Space Area(10,000 sq.m) | Number of Tenants(unit) | New Tenants of the year(unit) | Total Income of tenants(million Euro) | Accumulated Number of Graduated Tenants(unit) | Number of employees of Tenants(10000 person) |
|---|---|---|---|---|---|---|---|
| 2011 | 85 | 766.7 | 6923 | 1673 | 1,894.2 | 5137 | 13.1 |
| 2012 | 94 | 919.4 | 7369 | 1787 | 2,549.7 | 5715 | 13.2 |
| 2013 | 94 | 775.9 | 8204 | 2028 | 3,187.8 | 6515 | 14.7 |
| 2014 | 115 | 801.7 | 9972 | 2828 | 4423.7 | 7192 | 16.3 |

Source: Website of Torch High Technology Industry Development Center, MOST.

In terms of PhD employment, PhD graduates going to enterprises accounts for less than 10 percent of total PhD graduates in 2008, although there is a slightly increasing trend since 1996 (Figure 8). An important policy to encourage PhD graduates to work in industry was establishing postdoctoral workstations in companies. To date, there have been 4,275 post-doctoral workstations (China Post-doctoral Fellow Affairs Office, 2016), which is a significant number compared with the number of post-doctoral research centres, namely 458. A large number of post-doctoral workstations provide enterprises with young and high-level talents, which improves technological innovation capability and economic performance of the companies (China Post-doctoral Fellow Affairs Office, 2016).

**Figure 8**– Proportion of PhD graduates choosing enterprises in China




Source: China's Doctoral Quality Report Project Team, 2010

## 3.4 Assessment

As the Chinese economic growth slowed down since 2012 (a situation that the Chinese leadership termed "new normal"), the Chinese government responded with policies to curb the power of bureaucrats, simplify the process of starting business and reduce tax. The measures to streamline and simplify the process of registration business have positive impact. The number of newly registered businesses in 2014 increased by 46% compared with the number in 2013 (Xinhua Agency, 2015). The number in 2015 increased by 15% compared with that in 2014 (Chinese Economy Web, 2016). Since the end of 2015, the Chinese leadership including President Xi Jingping in various meetings discussed the supply-side economic policy. In contrast to demand-side policies which rely on capital investment, export and consumption, supply-side economics holds that the best way to stimulate economic growth is to lower barriers to production, particularly through tax cuts. The wealth-owners, rather than spending on direct "demand" purchases, will then be more enticed to invest in things that increase supply, such as new businesses, innovative goods and services. Cutting housing inventories, tackling debt overhang, eliminating superfluous industrial capacity, cutting business costs, streamlining bureaucracy, urbanization and abandoning the one-child policy are all examples of supply-side reforms.

The second major efforts that the Chinese government made in coping with economic slowdown are to promote "mass entrepreneurship and innovation". The policy mix includes providing tax relief for SMEs, creating incubators funded by the governments and providing them free of charge to the "makers" who start their own businesses, organizing competition in universities to encourage university students to start their own businesses, remove the legal and regulatory barriers for professors and scholars in public research institutions and universities to engage in technology transfer or start their own businesses. All these measures aim to generate sustainable and quality growth and implement the innovation-driven development strategy.

# 4. Smart specialisation approaches

## 4.1 Governance and funding of regional R&I

It is not uncommon in Chinese R&I policies and programmes that some industry sectors or technologies are picked by the governments as priorities for intensive investment. The rationale behind the prioritizing is that the country needs to concentrate the limited resources on certain important areas in which China is lagging behind the international technology frontier and the backwardness has negative impact on the social and economic development or national security. In the MLP announced in 2006, 13 technologies are prioritized which include core electronic devices, high-end generic chips and basic software, super large-scale integrated circuit manufacturing technology and associated techniques, the next generation broadband mobile telecommunication, high-end numerically controlled machine tools and basic manufacturing technology, the development of large oil-gas fields and coal-bed methane, large advanced pressurized water reactors and high temperature gas-coolant reactor nuclear power stations, water body contamination control and treatment, new genetically modified varieties, major new drugs, prevention and treatment of major infectious diseases such as HIV/ADIS and viral hepatitis, large passenger aircrafts, high resolution earth observation systems, manned space flights, and the moon probe.

The “Made in China 2025” announced in May 2015 also identifies 10 priority industrial sectors for policy and funding support: 1) New generation information technology; 2) Automated machine tools and robotics; 3) Space and aviation equipment; 4) Maritime equipment and high-tech shipping; 5) Modern rail transportation equipment; 6) New energy vehicles and equipment; 7) Power generation equipment; 8) Agricultural equipment; 9) New materials; and 10) Biopharma and advanced medical products. In the more recent policy document such as the 13$^{th}$ Five-Year Plan announced in March 2016, though it is not a R&I program, certain industries and sectors are also prioritized such as agriculture, energy, industry, environment, health, new-type urbanization, and so on.

Sub-national governments contribute about one-third of the total government investment in R&D. However, in terms of priority and agenda setting in the R&I policy, the central government is more authoritative than the local governments. The most important policies and guidelines are discussed and enacted at the level of the central government. Once the national plan and objective is set, the individual provinces or cities will make their respective plans and strategies, matching the national plan.

However, regional governments (provinces and municipalities) in China are granted a high degree of autonomy for regulating and managing the local economy and society (Xu, 2011). They make their own deliberation over the industries and technologies that they possess favourable conditions to develop, given their geographical condition, resource endowments, history and so on. Therefore, the prioritized industries or technologies chosen by a region may not be identical to the national ones. Quite often many regions compete for favourable policies and bank investment etc. to develop the nationally prioritized industries or technologies in their purview. In that case, it is up to the central government to pick the candidate regions. A recent case is the development of big data industry in the Southwestern province Guizhou. Guizhou is a less developed province located in the South-western part of the country. Because of its mountainous terrain and remote geographical location, the economy in Guizhou has been less developed than that of the most other provinces in the country. However, Guizhou government started as early as in 2014 to boost the development of big data industry by undertaking pilot projects of integrating data possessed by the provincial government, organizing big-data business model innovation competition, creating the first big-data trading market in the world and also hosting the first international big-data expo. All these efforts created momentum and attracted companies and talents to locate in Guizhou. In August 2015, in the Strategy of Big-Data Development announced by the State Council, it is explicitly mentioned that the central government supports creating a big-data experiment zone in Guizhou province. In 2016, the central government formally approved to establish a national-level experiment zone in the province.

In terms of S&T funding, the economically developed provinces can appropriate substantial budget to finance S&T activities, as the top five Chinese provinces are ranked in between 16th to 28th position in the world by the size of GDP. In the provincial governments, specialized departments such as the Beijing Municipal Commission of Science and Technology, Science and Technology Commission of Shanghai Municipality and Guangdong Provincial Department of Science & Technology, are responsible for managing S&T funds, similar as the Ministry of Science and Technology oversees a large amount of S&T investment by the central government.

## 4.2 Smart specialisation approaches

Feedback from the business community and stakeholders are important for enacting effective R&I policies. The Chinese policy makers often use the following channels to consult entrepreneurs and stakeholders: 1) expert committee. The discussion and enactment of major policies and guidelines usually involve a group of experts. For example, the expert committee of the 13th Five-Year Plan consists of 53 experts, including university professors, scholars from think tanks and senior officials from government agencies and renowned entrepreneurs. 2) consultation meetings. Periodically the Premier will invite entrepreneurs and scholars to discuss the to-be-launched policy documents and status of economic and social development. 3) visit and on-site meetings. Periodically the officials at the central government and local governments will visit companies, science parks, universities, research institutions and have discussion on-site with entrepreneurs, scholars and researchers on the issues related to R&D. 4) commissioned research. The governments at all levels commission scholars in universities, research institutions and think tanks to research policy instruments regarding R&I, through which scholars are involved in policy making related to R&I.

The Ministry of Science and Technology conducts technology foresight periodically. The Planning and Development Department of the Ministry and Chinese Academy of Science and Technology for Development, a think tank affiliated with the Ministry were responsible for the technology foresight exercise in 2013

## 4.3 Regional linkages to economic competitiveness

As early as in 2001, the Chinese government announced the “go global” strategy, encouraging Chinese companies to invest abroad, pursue product diversification, and promote brand recognition of Chinese companies in the EU and US markets. The outbound investment strategy was integrated with the continuous effort to promote foreign capital inflow to boost China's overall involvement in the global economic cooperation. The strategy made use of opportunities brought by China's anticipated accession into the World Trade Organization (WTO) in 2001. In around 2001, China amassed huge amount of foreign reserves, thus putting upward pressure on the foreign exchange rate of Renminbi, the Chinese currency. Pursuing the “go global” strategy can create demand for foreign reserves, thus alleviating the pressure on appreciating value of RMB. Since the launching of the going global strategy, Chinese companies’ interest in overseas investment has increased significantly. In 2014, the FDI (foreign direct investment) outflow from China amounted to €87.3 billion (USD 116 billion), making China ranked third in the world in terms of volume of outward FDI only after the US and Hong Kong, China (World Investment Report, 2015).

In the science area, Chinese scholars are also encouraged to collaborate with international partners. The National Natural Science Foundation of China established various projects to fund the joint research activities. For example, the NSFC set up a Sino-German Science Centre with its German counterpart Deutsche Forschungsgemeinschaft in 1998 to fund bilateral seminars and joint projects. The Ministry of Education also allocated funds to sponsor Chinese scholars and students’ overseas visiting research through the China Scholarship Council, an organization established in 1996 and affiliated with the Ministry.

## 4.4 Assessment

In spite of China's openness to market forces, however, Beijing's autocratic system of governance largely persists, providing ample room for the Chinese government to enact and implement industrial and innovation policy to enhance the technological capabilities of Chinese companies. This represents an advantage when the Chinese government set priorities for R&I activities. It allows the government to concentrate limited resources on certain areas that the country and the industry urgently need breakthroughs, avoiding that resources are too thinly spread.

However, China is a large country. Development across region is not homogeneous and balanced. The R&D investment and activities are largely concentrated in the coastal regions in the east. Although regional governments (provinces and municipalities) in China are granted a high degree of autonomy for regulating and managing the local economy and society, the challenge remains in the underdeveloped regions and areas. There have been efforts to address these disparities though. For example, in 2012, the Ministry of Education released the Revitalization Plan for Higher Education Institutes in Mid- and Western China. A more recent example is that the Guizhou province, which is geographically remote and economically less developed region in China, is approved by the central government to establish a national-level big-data experiment zone, providing conditions to develop big-data industries in the region.

# 5. Internationalisation of R&I

## 5.1 China in the global R&D system

In the last five years China has increased its investment in research and innovation, with the aim to turn China from the manufacturing centre of the world into world-leader on innovation by 2050 (Innovation 2050, 2009). The volume of innovation output is steadily growing, which is reflected by the significant increase of its share in global patenting and global R&D investment. China is ranked second and first in the world respectively in terms of total R&D expenditure and headcount of R&D in 2014 (OECD, 2015). The annual growth rate of patents and trademarks of China is 12.5% and 18.2% (World Intellectual Property Indicators, 2015). China ranked 29th of all economies in the Global Innovation Index 2015 and moved up to 18th position in the innovation quality ranking, retaining the top place among the middle-income economies and narrowing the gap that separates it from the high-income group (Global Innovation Index, 2015). In addition, China's innovation capabilities ranking rose to 28th in 2015 from 48th in 2006 (Global Competitiveness Report, 2015).

The rapid expansion of degree production in China in science and engineering fields is particularly noteworthy as it is more than double US levels. In 2013, science and engineering degrees represented 48.7% of all new university degrees awarded in China (compared with just 16.7% in the United States and 31%, 27%, 35% respectively in the United Kingdom, France and Germany). The yawning gap is most evident in engineering, which represents nearly 33% of all new university degrees awarded in China, compared with 20.8% in the United States and nearly 26.1% in EU. In absolute terms, China's science and engineering doctorate production has grown by an average of 18% per year since 1998 (thanks in part to a lower base level). By 2012, China's S&E doctorate production had surpassed US levels (National Science Foundation, 2016).

According to Thomson Reuters' Science Citation Index, China ranked second in the world in research output as measured by number of core papers published in research journals (Thomson Reuters 2014). China also ranked fifth in number of citations in 2013 and fourth in number of highly cited papers published in 2003–2013, which rank in the top 1% by citations for field and year indexed in the Web of Science (Institute of Scientific and Technical Information of China, 2015). In 2015, China trailed only the United States and Japan in patent filings under the Patent Cooperation Treaty (PCT) administered by the World Intellectual Property Office (World Intellectual Property Organization, 2015). Furthermore, in 2015, two large Chinese telecommunications equipment manufacturers, Huawei Technologies and ZTE, filed 3,898 and 2,155 patents, respectively, which ranked them first and third in the worldwide ranking of top PCT patent applicants. At the US Patent and Trademark Office, the number of patent applications originating in China grew 14% from 2012 to 2013 alone, a rate that is higher than those of the other top countries and regions (the United States, Japan, Germany, South Korea and Taiwan) (US Patent and Trademark Office, 2014). According to the Institute of Scientific and Technical Information of China (2015), there are 7 subjects in which Chinese publications received the second largest number of citations in the world, namely, agricultural science, chemistry, computer science, engineering, material science, mathematics, pharmacology and toxicology. In environmental ecology and physics, China ranked the 3$^{rd}$ in terms of number of citations. In biology and bio-chemistry and geology, China ranked the 5$^{th}$ in the world.

## 5.2 Main features of the international cooperation policy

The Department of International Cooperation, Ministry of Science and Technology is responsible for bilateral and multilateral inter-governmental S&T cooperation and exchange with relevant international organizations, the official agreements of S&T cooperation, and examines and coordinates major projects of non-official S&T cooperation and exchanges (MOST, 2003).

The overall purpose of China's participation in international S&T cooperation is to open up the S&T system and step into exchange and cooperation, also known as nation's "reform & opening up" process. As to move China's R&I capacity towards the global frontier, it requires the integration with the global research enterprise, an open innovation environment, and the attraction of S&T resources globally. It is also often driven by the need to address domestic development and societal challenges.

### 5.2.1 National participation in intergovernmental organisations and schemes and multilateral agreements

There are over 200 intergovernmental organisations and schemes in the science and technology domain that China participates in. The main forums are United Nations Educational, Scientific and Cultural Organization, World Meteorological Organisation, World Intellectual Property Organisation, Food and Agriculture Organisation of the United Nations, the International Council for Science, and so on. The main agencies involved are Ministry of Science and Technology, National Natural Science Foundation of China, Chinese Academy of Sciences, China Association of Science and Technology, universities, research organisations and companies.

Moreover, China takes part in many large-scale research infrastructure programmes and big science collaborations. China participates in building the Galileo satellite navigation system as a non-EU member and is one of the seven member states in International Thermonuclear Experimental Reactor, the international nuclear fusion research and engineering project. Also, China has cooperation agreements with the European Organisation for Nuclear Research (CERN), and contributes to the accelerator construction costs of CERN's Large Hadron Collider.

### 5.2.2 Bi and multi lateral agreements with EU countries

There are long standing bilateral agreements between China and Germany, France, the UK and Italy. Also, since the development of relations between EU and China, smaller EU Member States, for example, Austria, Denmark, Finland, Ireland, Norway, Sweden, The Netherlands, Portugal, and Croatia, have intensified bilateral cooperation with China, involving the MOST. Bilateral agreements with EU countries typically provide schemes for supporting the mobility of researchers, the establishment of joint institutional research structures, arrangements of collaborative research between funding organisations, research institutions, and government authorities. Areas of cooperation in these agreements include information technology, nanotechnologies, biotechnologies, life science, energy, environment, and climate change more recently. The main agencies of bilateral agreements between China and EU Member States include the French Programme for Cooperation with China, France-China Particle Physics Laboratory, Sino-German Centre for Research Promotion, International Sino-German Trans regional Collaborative Research Centres, UK-China Partners in Science, Sino-Dutch Centre for Preventive and Personalised Medicine, the China-Finland Nanotechnology Strategic Mutual Cooperation Initiative and so on.

The EU-China Science & Technology Agreement was signed in December 1998. An annual joint steering committee is held between the Chinese Ministry of Science and Technology (MoST) and European Commission's DG Research and Innovation. The S&T Agreement was renewed in 2004, 2009 and 2014. The EURATOM-China Agreement for R&D Cooperation in the Peaceful Uses of Nuclear Energy (R&D-PUNE Agreement) was signed in April 2008. It is implemented by a joint steering committee co-chaired by DG Research and Innovation representing EURATOM, and MoST.

Since 2012, China and EU have held annual EU-China Innovation Dialogues for regular communications on issues of technological and industrial R&D cooperation. The EU-China Joint Declaration on Innovation Cooperation Dialogue (20 September 2012) decided to create an official platform for exchanges and cooperation on innovation between both sides. And the main basis now for EU-China cooperation is summed up in the EU-China 2020 Strategic Agenda for Cooperation (see European Commission, 2014).

In addition, the Chinese Ministry of Science and Technology has published the first call for proposals under the EU-China Co-Funding Mechanisms for Research and Innovation further to the political agreement reached at the 2nd EU-China Innovation Cooperation Dialogue, which builds the Co-funding Mechanism that will support mainland China-based research and innovation organisations participating in joint EU-China projects under Horizon 2020 (European Commission, 2015).

## 5.3 Assessment of options for JRC collaborations

The partnership between the EU and China has deepened over the years incorporating a greater number of topics. In 2003, in the area of S&T, a Framework Agreement for establishing industrial policy dialogue was established. In 2012, the setting-up of the EU-China Higher Education Platform for Cooperation and Exchange was agreed, while in January 2014, New EU-China Intellectual Property Cooperation was launched building on two previous projects in this area.

The main basis for EU-China cooperation is summed up in the EU-China 2020 Strategic Agenda for Cooperation (Delegation of the European Union to China, 2013), which was adopted on 21st November 2013 at the occasion of the 16th EU-China Summit. An important vehicle for S&T cooperation established is the EU-China Innovation Cooperation Dialogue, whose first meeting took place in November 2013. The meeting acknowledged cooperation progress in areas such as food, agriculture and biotechnology, sustainable urbanisation, and aviation, as well as EU-China cluster cooperation. It was also proposed to strengthen ICT cooperation in key topics such as future telecommunications (5G), smart cities and the internet of things.

EU-China cooperation related to research and innovation has followed a two pronged strategy with on the one hand striving for increasing openness and access to each other's funding programmes and on the other specific cooperation in strategic fields and key thematic areas.

EU-China R&D cooperation in strategic areas is being implemented via increasing access to each other's funding programmes. The EU's FP7 and now Horizon 2020 are open to participation from China including International Incoming/Outgoing Fellowships, supporting researcher mobility. In addition, two programmes have recently been specifically designed to provide specific support to EU-China R&DI cooperation.

The first of these programmes relates to funding from the Chinese side, the China-EU Science and Technology Cooperation Special Programme. Launched on January 22, 2013 by MOST, it is designed to fund China-EU Science and Technology Cooperative Projects in themes from urbanisation and renewable energy to ICT and health. Projects require at least 2 European partners and funding of up to 3 million RMB (0.35 million Euros) is for the Chinese side only.

Some of the main areas of current collaboration between China and JRC are:

I. JRC Collaboration with the Academy of Sciences and future prospects

There is already a long standing and fruitful cooperation between the Joint Research Centre and the Chinese Academy of Sciences. Both JRC and the former CEODE institute-replaced by Institute of Remote Sensing and Digital Earth (RADI) in 2012 after consolidation of two mayor institutes- have cooperated successfully in the past five years (2008-2013) under a Memorandum of Understanding.

Both RADI and JRC agreed to sign the agreement during the EU-China Summit followed by a joint technical workshop to kick off the collaboration and better define the implementation areas.

The JRC is open to discuss further areas for potential collaboration with CAS such as air quality. It has already established exploratory contacts with CAS Institute of Atmospheric Physics (IAP) in this area of expertise, and there are prospects for cooperation in the near future. Previous collaborations of JRC Institutes with other CAS institutes other than RADI include:

- China Institute of Atomic Energy, Institute of Nuclear Energy Safety Technology
- Centre for Chinese Agriculture Policy
- Key lab for Biomedical Effects of nanomaterial's and nanosafety
- Institute of Geochemistry
- Institute of geographical sciences and natural resources research.
- Institute of Soil and water conservation (partner with JRC under H2020 project to be signed)
  Institute of Soil Science (partner with JRC under H2020 project to be signed

Under the frame of the EU-Sino Panel on Land and Soil, IES and CAS take part of the Scientific Committee and JRC has collaborated with a number of institutes with a very positive experience. There is a genuine interest in continuing and enhancing collaboration within this framework in the future.

II. Cooperation with the Ministry of Science and Technology (MOST)

DG JRC has an interest in the (draft) Plan for the *Major Special Programme on Air Pollution Prevention and Control* under MOST, and has established a dialogue with MOST-ACCA 21 to identify possibilities of collaboration in this context, as there's a significant convergence between the objectives of the Plan and the JRC activities on air quality.

ACCA 21 is an agency habilitated by MOST in charge of the implementation of the Chinese plan for the *Major Special Programme on Air Pollution Prevention and Control*. For the future implementation, a national research initiative is under preparation.

In a recent mission to Beijing (20-24 April 2015), a JRC delegation met MOST and ACCA 21 representatives as well as a number of national experts participating in the scientific committee for the implementation of this plan, including Tsinghua University, CRAES (Ministry of Environmental Protection), etc. These exploratory talks on opportunities to inform policy making in the area of air quality are expected to continue in the near future.

III. Other JRC cooperation with China in the field of Space research (remote sensing and digital earth observation)

DG JRC's cooperation with China has been developed over the last two decades in the field of Earth Observation. In the immediate aftermath of the devastating Sichuan earthquake in 2008 the EC through DG JRC began its successful cooperation with the Institute of Remote Sensing and Digital Earth of the Chinese Academy of Science (CAS); JRC staff was deployed in China for supporting CAS-RADI in the analysis of remote sensing imagery in support to relief efforts by China.

Since then the collaboration has expanded to the successful testing of the Global Human Settlement Layer production workflow using Chinese satellite data. This has resulted in the processing of large amounts of satellite data demonstrating the capacity to map the entire territory of China using CBERS-2B satellite data.

IV. Other JRC Cooperation with China and future prospects

DG JRC has established an active and wide-ranging scientific cooperation with several Chinese Universities and Government bodies[5] in the areas of:

- nuclear safety and security
- air quality
- disaster management
- transport research and vehicle emissions standards
- food safety and security

A selection of top research partners where potential future collaboration may be developed with DG JRC are set out in the annex.

DG JRC's cooperation with China also contributes to inter-governmental initiatives such as the Group on Earth Observations (GEO).

DG JRC is supporting joint validation of the 'GlobalLand30' product developed by China. A team from Tsinghua University visited DG JRC's laboratories in Ispra, Italy, in May 2014 for an intensive inter-comparison exercise between DG JRC and Tsinghua's land cover products. Both teams support the GEO's proposed 'Land Cover Africa' Working Group, which also involves the US Department of the Interior. A workshop on Land Cover Mapping is planned and will involve joint preparations between technical experts.

## 5.4 R&I linkages between countries in this study

**China-U.S. Science and Technology collaboration**

Since the China-U.S. Science and Technology Cooperation Agreement was signed in 1979, an era of robust government-to-government S&T collaboration between China and US had begun. These exchanges have helped cooperative research between China and US in a diverse range of fields, including fisheries, earth and atmospheric sciences, basic research in physics and chemistry, a variety of energy-related areas, agriculture, civil industrial technology, geology, health, and disaster research (U.S. Department of State, 2012). The S&T agreement is renewed every five years, and competent government departments of the two countries take turns in organizing meetings of the China-U.S. Joint Committee on Science and Technology Cooperation every two years (MOST, 2011a). The newest S&T agreement was released in 2012 and the 15th China-U.S. Joint Committee on Science and Technology Cooperation was held in November 2014, which continued to advance a range of activities, including following areas:

- Clean Energy
- The China-U.S. Clean Energy Research Center (CERC) was establishment in November 2009. Four strategic important areas are identified, including advanced coal technology consortium, clean vehicles consortium, building energy efficiency consortium and energy-water.
- Climate Change
- In 2013, the China-U.S. Climate Change Working Group (CCWG) was established, which undertook collaborative activities on vehicles, smart grids, carbon capture, utilization and storage, energy efficiency, greenhouse gas data management and industrial boilers.
- Marine and Fishery
- The Marine and Fishery Science and Technology Protocol was signed in May, 1979, and the 18th Joint Working Group Meeting was held in 2011. The five major areas of cooperation are oceanographic data and information, the role of the oceans in

[5] For example, Chinese Ministry of Science and Technology (MOST), Chinese National Satellite Meteorological Centre, the Institute of Remote Sensing and Digital Earth (RADI) from the Chinese Academy of Science (CAS), Uni. Tongji, Tsinghua University, Beijing Normal University.

climate change, marine policy & management, international marine affairs, living marine resources, and polar sciences.

- China's State Oceanic Administration and National Oceanic and Atmospheric Administration (NOAA) of U.S. agreed to a 2011-2015 Framework Plan for Ocean Science and Technology Cooperation, which has the potential to advance U.S. science by improving China's timely data sharing.
- Agricultural
- MOST and Agricultural Research Service (ARS) of U.S. signed annexes for Dairy Production and Water Saving Technology research and a Letter of Intent to continue its bilateral dialogue on food security research in biotechnology, water saving technology, and gene bank technologies.
- Other fields
- Robotics, portable fuel cells, non-oxide glasses, metamaterials, ballistics, and nanomaterials for electrochemical systems, global immunization, outbreak response, surveillance, and epidemiologic training, earthquake studies, basic sciences, pollution prevention and management.

Besides, there are people-to-people exchanges in S&T areas, including 2015 Young Scientist Forum in Beijing and 2015 Young Scientist Forum in Washington, D.C, which enhance the S&T connection between two countries.

**China-Brazil Science and Technology collaboration**

Science and technology cooperation between China and Brazil is developing. The China-Brazil Science and Technology High-level Dialogue was held on April 12, 2011 in Beijing, which emphasized the cooperation on climate change, energy crisis, food security, renewable energy, nanotechnology, agricultural science and food safety, information technology and space technology (MOST, 2011b). Moreover, new energy and new materials, agricultural technology and food safety, information technology and the Internet, innovation and innovation environment are four major areas mentioned by the MOST of China and the Ministry of Science, Technology and Innovation of Brazil in 2015.

**China-India Science and Technology collaboration**

Science and technology cooperation between China and India is also developing. The Fourth BRICS (Brazil, Russia, India, China and South Africa) Senior Official Meeting on Science, Technology and Innovation Cooperation, which was held in 2015, outlined the main areas that China and India would cooperate, including innovation and technology transfer, new energy and renewable energy, energy efficiency, pharmaceuticals and biotechnology, high-tech parks and incubators, geo-spatial technologies and applications, aerospace and outer space exploration, astronomy, earth observation, food security and sustainable agriculture. More specifically, a memorandum signed by State Oceanic Administration People's Republic of China and Ministry of Earth Sciences of India in 2015 stressed the cooperation on marine science and technology, climate change, polar and cryospheric fields.

**China-Mexico Science and Technology collaboration**

China-Mexico Joint Declaration, which was released in 2013, emphasized the cooperation in clean and renewable energy, bio-technology, nano-technology, urban environmental pollution prevention and control, infectious disease prevention and water resources utilization. The Sixth China-Mexico S&T Committee, which was held in 2014, stressed the S&T cooperation in the fields including clean and renewable energy, semiconductor lighting, geospatial information technology, aviation and space technology, biotechnology, nanotechnology, medical and health research, disease surveillance, forestry technology, water resources, basic science and innovation studies (MOST, 2014).

## 5.5 Researcher mobility and join laboratories

### 5.5.1 Researchers from abroad and national researchers

China currently possesses two main national schemes (111 Plan and Thousand Talents Programme). The goals of these programmes are attracting researchers from abroad and encouraging the return of nationals. The Higher Education Institution Innovation and Talent Plan (111 Plan, initiated in 2006), seeks to attract 1,000 leading scholars from abroad to work in China's top universities listed in the 985 Programme and 211 Programme. The ultimate goal of the plan is to build world-class universities in China. The Thousand Talents Programme is the largest existing national scheme of attracting nationals to return, which aspires to recruit 2,000 Chinese national specialists to return and work on state-targeted areas. The programme has two categories for recruitment: an Innovation category, which recruits leading scientists and engineers to work in national key projects, key academic disciplines and key labs; and an Entrepreneur category, which targets business elites to start technologically sophisticated enterprises in key industries. In addition, the China Scholarship Council (CSC) is the main government agency for sponsoring Chinese nationals to study abroad, with a mandatory return phase. CSC funds some 185 projects in five categories for overseas training. Those programmes have not only attracted researchers from abroad, but also helped to train domestically talents. Also, the number of Chinese students going abroad and returns are both increasing and the gap between students and talents going abroad and returnees are shrinking (Table 14):

**Table 14** Number of Chinese Students going abroad and returnees, 1978-2014

| Year | Students Going Abroad | Students Returnees |
|---|---|---|
| 1978 | 860 | 248 |
| 2000 | 38,989 | 9,121 |
| 2010 | 284,700 | 134,800 |
| 2011 | 339,700 | 186,200 |
| 2012 | 399,600 | 272,900 |
| 2013 | 413,900 | 353,500 |
| 2014 | 459,800 | 364,800 |

Source: National Bureau of Statistics of China

The number of European students (including students from EU and non-EU countries) studying in China is increasing, from 16,463 in 2005 to 66,746 in 2015, which respectively represented 11.6 and 16.8% of all international students studying in China (Ministry of Education, 2016). Both EU countries and US are attractive for Chinese students. Some 20.9% of all Chinese citizens enrolled in tertiary education abroad study in EU-21, while 30.9% in the United States. The students from China account for 22% of all international students enrolled in tertiary education in the OECD area, the highest share among all reporting countries (Education at a Glance, 2015).

### 5.5.2 Scope of joint laboratory collaboration in country or in Europe

There is an increasing number of foreign-invested R&D centres in China, which have become a hub for (Chinese and EU) researchers to seek cooperation with industry, providing opportunities for industry-academy collaboration. The large gap between industry and academic research presents a challenge for cooperation. However, the demand for technology in the Chinese side and EU organizations' ability to provide innovative solutions leads to the recommendation to strengthen the use of the EU SME Centre in Beijing to improve connections between EU firms with Chinese research and industry stakeholders (Science, Technology and Innovation Performance of China, 2014).

Two main documents about policies promoting joint labs are Administrative Measures on International Cooperation in S&T centres published by MOST, and International

Cooperation Joint Labs Program published by the Ministry of Education. There are lists of International Joint Research Centres published by MOST and International Joint Labs published by the Ministry of Education among years. In the lists, all joint research centres and labs are located in universities and colleges, or based on several higher education institutions. Apart from that, there are other joint programmes, joint research centres and calls for projects organized by MOST.

The following are some important joint research centres, virtual or physical:

- China-Italy Design and Innovation Centre, Tongji University, Shanghai
- Sino-Swedish Joint Research Centre of Photonics
- Sino-UK Geospatial Engineering Centre, The University of Nottingham, UK
- UK-China Network of Clean Energy Research
- UK-China Stem Cell Partnership Initiative
- Sino-French Research Program in Mathematics
- Joint Research Institute for Science and Society (Sino-French research)
- Sino-French Laboratory in Computer Science, Automation, the Institute of Automation of the Chinese Academy of Sciences, Beijing
- Sino-French Research Centre for Life Sciences and Genomics, Shanghai Jiao Tong University, Shanghai
- Sino-French Institute for Engineering Education & Research
- Sino-German Life Science Platform, Beijing
- Sino-German Centre for Research Promotion, Beijing
- Sino-German Initiative on Marine Sciences, Ocean University of China, Qingdao
- Sino Austria Bio-marker Centre, Peking University, Beijing
- Portugal-China Joint Innovation Centre for Advanced Materials, Zhejiang University, Hangzhou
- China - Croatia Ecology International Joint Research Centre
- Danish-Chinese Centre for the Theory of Interactive Computation, Tsinghua University, Beijing
- Danish-Chinese Centre for Molecular Nano-Electronics, Chinese Academy of Science, Beijing
- Danish-Chinese Centre of Breast Cancer Research, Chinese Academy of Science, Beijing
- "Smart Energy in Smart Cities", China – Netherlands Joint Scientific Thematic Research Programme, Chinese Academy of Science, Beijing

## 5.6 R&D related FDI

Foreign companies have started to set up R&D centres in China since the 1990s. A large number of foreign companies' R&D centres were established in the 2000s. In 2012 including Hong Kong, Macao and Taiwan invested-enterprises, the number of foreign-invested companies with R&D departments amounted to 10,146, accounting for 22.1% of the enterprises above designated size (whose annual revenue is greater than RMB 20 million) with R&D departments. The number of the independent foreign R&D centres in China has increased rapidly, amounting to more than 1400 by the end of 2010. Among them 700 were set up by multinational corporations (Wang et al., 2014).

R&D expenditure of foreign-invested companies grew rapidly from €13.5 billion (RMB 100.2 billion) in 2000 to €21.8 billion (RMB 176.4 billion) in 2012, by 17 times. The R&D expenditure by foreign-invested companies accounted for 24.5% of all large- and medium-enterprises' R&D expenditure in China. In some provinces such as Shanghai, R&D expenditure of foreign firms accounted for more than half of the industrial R&D expenditure. In 2006 R&D staff employed by foreign-invested companies amounted to 140,000. In 2012 the number increased to 770,000, accounting for 25.3% of total number of R&D staff in the large- and medium-enterprises in China. The number of staff in the R&D centres of Fortune 500 also increased rapidly. Microsoft Asia-Pacific R&D Group employed dozens staff in 1998, but it employed more than 3,000 in 2013, accounting for 10% of global R&D personnel. General Electronic China Technology

Centre has developed rapidly since its inception in 2000. It employed 2800 people in 2013, accounting for nearly half of its global R&D personnel.

Foreign companies were attracted by the large Chinese market and supply of high-calibre human resources to set up their R&D centres in China. They are also incentivized by the favourable policies enacted by the central and local governments in China. Those policies include tax relief for customs duties on imported equipment, value added tax

## 5.7 Assessment

China has become an important global player in terms of R&D and innovation. The total volume of innovation resources is steadily growing, which leads to the significant increase of global R&D input such as investment and its share in global R&D output such as patenting. In addition, the Chinese government has also been committed to implementing the innovation-driven development strategy. China has been opened up for foreign companies to invest and particularly for setting up R&D centres. All these favourable conditions have been providing ample opportunities for China to cooperate with foreign countries such as the European countries.

Over the last decade or so, multiple cooperation programme and initiatives have been established between China and Europe. Some prove to be very successful and some just took off from the ground. The future efforts would be needed in the area that both sides saw opportunities and where strengths are complementary. Given that the landscape of R&D activities in China is rapidly changing, and both the European and Chinese sides are continuing to define each other's own priorities, it would be important for both governments to continuously monitor general trend, study new developments and engage in discussion.

# 6. Conclusions

The People's Republic of China has experienced rapid economic growth over the last three decades, making China the second largest economy in the world by 2014, with GDP of €7.78 trillion (RMB 63.5 trillion) or €9,913 ($13,170) per capita (current price and PPPs, OECD, 2015). However, the economic growth in China slowed down in the recent years. The GDP annual growth rate dropped from 9.49% in 2011 to 6.9% in 2015 (OECD, 2015; National Bureau of Statistics of China, 2016), entering in a stage what the Chinese leadership called "new normal". As China in 2014 is with GDP per capita of € 9,913 (13,171 USD, current prices and PPPs) and a slower economic growth, it faces challenges of sustaining its economic growth and social development, in order to escape the "middle income trap"[6].

To escape the middle income trap, the Chinese government calls for implementing the innovation-driven development strategy. Since 2005 China has become the second largest spender on R&D globally. In 2014, Gross Expenditure on R&D (GERD) in China reached €277.6 billion (USD 368.7 billion, current price and PPPs). The GERD increased from €178.0 billion (USD 247.8 billion, current price and PPPs) in 2011 to €277,554 million (USD 368.7 billion, current price and PPPs) in 2014, representing 56% of increase over the four years (OECD, 2015). The R&D expenditure performed by industry, Public Research Institutions (PRO), and Higher Education Institutions (HEI) amounted to €123.2 billion (RMB 1.0 trillion), €23.6 billion (RMB 192.6 billion) and €11.0 billion (RMB 89.8 billion), which correspond to 77.3%, 14.8% and 6.9% of the GERD (China Statistical Yearbook on Science and Technology, 2015). China possesses the largest S&T workforce in the world which is composed of 5.0 million R&D personnel or 3.15 million full-time equivalent in 2013 (China Statistical Yearbook on Science and Technology, 2014). Even though China has become the second largest R&D spender in the world and possesses the largest S&T workforce, the success of driving the economic growth through innovation is not guaranteed, because of the following challenges.

First of all, although China invests intensively in R&D and Chinese companies have grabbed large market shares in many products, Chinese scientists have yet to reach the frontier of scientific research except in a few fields, for example, agricultural science, chemistry, computer science, engineering, material science, mathematics, pharmacology and toxicology, in which Chinese publications received the second largest number of citations in the world, Chinese companies have yet been able to enter some high value-added niche markets, for certain key components and equipment which has profound impact on national security, China is still reliant on foreign products and technologies. To tackle this challenge, after the MLP was launched in 2006, the Chinese government soon started the National Science and Technology Major Project, supporting R&D in technologies such as general purpose computer chip, wireless communication, high-precision machine tools, nuclear power, and HIV/AIDS treatment. In the 12$^{th}$ Five-Year Plan (2011-2015) and 13$^{th}$ Five-Year Plan (2016-2020), the Chinese government continues to sponsor research in these frontier technology fields and also the projects that are the key to the national security and industrial competitiveness.

[6] The middle income trap is a theorized economic development phenomenon, where a country is not able to further increase its per capita income after reaching a certain level of income. Typically, the countries falling into the middle income trap suffer from low investment, slow growth in the secondary industry, limited industrial diversification and poor labour market conditions. The big challenge for such countries is to moving from resource-driven growth that is dependent on cheap labour and capital to growth based on high productivity and innovation. For example, some newly industrialised economies such as South Africa and Brazil have not, for decades, graduated from what the World Bank defines as the 'middle-income range' since their per capita gross national product has remained between €7,728.6 ($10,000) to €9,274.3 ($12,000) at constant 2011 prices.

Second, a major weakness of the Chinese innovation system is the fragmentation of the funding system. The first public R&D funding program was established during the period of 1981-1985. Over the years, Spark Programme, the National Natural Science Foundation of China, the 863 Programme, Torch Programme, the 973 Programme and some other 90 funding schemes were established. Because these programmes were set up in different period and managed by different government agencies, they lack coordination.

In January 2015, the Chinese government announced a major reform on the S&T financing system, which is to be finished by 2017. One of the objectives of the reform is to reduce the fragmentation and enhance the harmonization of the S&T funding system. The government will integrate more than 90 funding programmes managed by some 40 government departments into five major ones, which include the National Natural Science Foundation of China (NSFC), National Science and Technology Major Project, National R&D Key Program, Technological Innovation Introductory Fund and Base and Talent Program.

In the old system, each government agency manages its R&D programmes separately. Duplicate research may have been conducted due to a lack of communication and coordination between funding organizations. In the new S&T funding system, a joint committee will be established to oversee fund allocation, aiming to increase communication and coordination among government departments. The representatives of the ministries such as Ministry of Science and Technology, Ministry of Finance and National Development and Reform Commission will be members of the joint committee. The committee will make important decisions; including proposing call-for-proposal, selecting appropriate professional organizations to manage the projects, listing reviewers and terminating stalled projects. In addition, a strategic consultation and comprehensive review committee will be created, which is composed of representatives from science community, industry and economists. They will consult the joint committee regarding the trend of scientific research, industry development and strategy of S&T and innovation.

Third, another weakness of the S&T funding system before the reform of 2015-2017 was that the government agencies are responsible for the whole process of fund allocation, from call-for-proposal, receiving and evaluating applications, to managing the funded projects. Because all the power is concentrated in the government, when there is lack of supervision and transparency, it can easily give rise to corruption and abuse. In the new system, government departments will not manage research projects. Instead, independent and professional organizations will be created to select the applications and manage the funded projects. The organizations will have to compete with each other to gain the service contracts offered by the government agencies. These specialized organizations will report to the joint committee and sign contract with the government agencies. They will operate according to a high standard of efficiency and integrity.

Fourth, in spite of significant investment in R&D, Chinese universities' patent technology transfer rates remain low, ranging from 2 percent (People's Daily 2015) to 5 percent (MOE 2015) annually. The national rate is 10 percent (NBD 2014). Besides technology maturity gaps between universities' basic R&D research and industry's commercial applications, one of the main reasons for such a low technology transfer rate is a flawed regulatory system, which suffers from shortcomings involving incentives, ownership and decision-making authority, protection, policy impediments, and distribution of profits.

As one of the measures to tackle the challenge, the Law on Promoting the Transformation of Scientific and Technological Achievements was amended in August 2015 and came into force on October 1st, 2015. The original law was passed in 1996. The amendment 20 years after its passage aims to promote technology transfer from public research organizations and higher education institutions, incentivize R&D staff in the public research organizations and higher education institutions to start their own businesses and make innovations, and also create good policy environment for technology transfer. The new law clarifies IP ownership and decision-making authority over patents and technology, reduces legal risks associated with the transfer or sale of university-owned IP, and removes the policy impediments to university researchers' entrepreneurial start-ups and eventual public listing.

China has become an important global player in terms of R&D and innovation. The total volume of innovation resources is steadily growing, which leads to the significant increase of global R&D input such as investment and its share in global R&D output such as patenting. In addition, the Chinese government has also been committed to implementing the innovation-driven development strategy. China has been opened up for foreign companies to invest and particularly for setting up R&D centres. All these favourable conditions have provided ample opportunities for China to cooperate with foreign countries including European countries.

China has established science and technology cooperation with the European Union (EU) since the signing of EU-China Science and Technology Agreement in 1998. A multitude of formal science and technology agreements have been established between China and Europe at both the EU and individual Member State level. These agreements promote scientific exchange, research collaboration and coordination among national authorities. Chinese researchers are active participants in the EU Framework Programmes. The future, efforts would be needed in the area that both sides see opportunities in areas where the strengths are complementary. Given that the landscape of R&D activities in China is rapidly changing, and both the European and Chinese sides are continuing to define each other's own priorities, it would be important for both governments to continuously monitor general trends, study new developments and engage in discussion to develop cooperation in areas of mutual interest.

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## Abbreviations

| | |
|---|---|
| BERD | Business Expenditures for Research and Development |
| BES | Business Enterprise Sector |
| CAS | Chinese Academy of Sciences |
| CERN | European Organisation for Nuclear Research |
| CSC | China Scholarship Council |
| CPC | Chinese Communist Party |
| EU | European Union |
| EU-28 | European Union including 28 Member States |
| FDI | Foreign Direct Investments |
| GBOARD | Government Budget or Outlays on R&D |
| GERD | Gross Expenditure on Research and Development |
| GEO | Group on Earth Observations |
| GOV | Government Sector |
| 111 Plan | Higher Education Institution Innovation and Talent Plan |
| HEI | Higher education institutions |
| JRC | Joint Research Centre (a Directorate-General of the European Commission) |
| LME | Large- and Medium- Enterprise |
| MLP | Medium- and Long-term National Plan for Science and Technology Development: 2006–2020 |
| MIIT | Ministry of Industry and Information Technology |
| MOE | Ministry of Education |
| MOST | Ministry of Science and Technology |
| 973 | National Basic Research Programme |
| 863 | National High-Tech Research and Development Programme |
| NDRC | National Development and Reform Commission |
| NSFC | National Natural Science Foundation of China |
| PRO | Public Research Organisations |
| R&I | Research and Innovation |
| R&D | Research and Development |
| RADI | Institute of Remote Sensing and Digital Earth |
| S&T | Science and Technology |
| SME | Small- and Medium- Enterprises |

## List of Figures

## List of Tables

# Annex 1 - List of selected main research performers by area

| Areas | Name | Website |
|---|---|---|
| Air Quality | Tsinghua University, School of Environment | http://www.tsinghua.edu.cn/publish/enven/index.html |
| | Peking University, School of Environment and Energy | http://219.223.222.210/Default.aspx |
| | Chinese Research Academy of Environmental Sciences | http://www.craes.cn/cn/SUSTIANH2O/home.htm |
| | Research Centre for Eco-Environmental Sciences, CAS | http://english.rcees.cas.cn/ |
| | Fudan University, Department of Environmental Science and Engineering | http://environment.fudan.edu.cn/en/Default.aspx |
| Land and Soil | Institute of Soil and Water Conservation, CAS & MWR<br>Institute of Soil and Water Conservation, Northwest A&F University[1] | http://english.iswc.cas.cn/ |
| | Institute of Soil Science, CAS | http://english.issas.cas.cn/ |
| | Research Centre for Eco-Environmental Sciences, CAS | http://english.rcees.cas.cn/ |
| | China Geological Survey, Ministry of Land and Resources of China | http://en.cgs.gov.cn/ |
| | College of Resources and Environmental Sciences, China Agricultural University | http://zihuan1.cau.edu.cn/index.htm l |
| Water | State Key laboratory of Pollution Control & Resource Reuse, Nanjing University & Tongji University | http://hjxy.nju.edu.cn/skl2/?l2/ |
| | Tsinghua University, School of Environment | http://www.tsinghua.edu.cn/publish/enven/index.html |
| | Peking University, School of Environment and Energy | http://219.223.222.210/Default.aspx |
| | Harbin Institute of Technology, School of Municipal and Environmental Engineering[2] | http://me.hit.edu.cn/english/index.html |
| | Research Centre for Eco-Environmental Sciences, CAS | http://english.rcees.cas.cn/ |
| Transportation -related and Emission | Vehicle Emission Control Centre, Ministry of Environmental Protection of China | http://www.vecc-mep.org.cn/eng/ |
| | Transport Planning and Research Institute, Ministry of Transport of China | http://www.tpri.org.cn/ |
| | Centre for Air Pollution Control Technology, CAS | http://hehong.rcees.ac.cn/en/index.asp |
| | Tsinghua University, School of Environment | http://www.tsinghua.edu.cn/publish/enven/index.html |

| | | |
|---|---|---|
| | School of Mechanical Engineering, Shanghai Jiao Tong University | http://me.sjtu.edu.cn/English/Default.aspx |
| Digital earth (remote sensing, agriculture, land mapping) | Peking University, School of Earth and Space Sciences | http://sess.pku.edu.cn/list/?151_1.html |
| | Wuhan University, School of Remote Sensing and Information Engineering | http://rsgis.whu.edu.cn/ |
| | School of Geography, Beijing Normal University | http://geo.english.bnu.edu.cn/ |
| | Institute of Remote Sensing and Digital Earth, CAS | http://english.radi.cas.cn/ |
| | National Administration of Surveying, Mapping and Geo-information of China | http://en.nasg.gov.cn/ |
| Construction Standard | School of Architecture, Tsinghua University | http://www.arch.tsinghua.edu.cn/ghqt/homePage/homePage.html |
| | College of Civil Engineering, Tongji University | http://civileng.tongji.edu.cn/en/ |
| | Southeast University, School of Architecture | http://arch.seu.edu.cn/home/index.php# |
| | Ministry of Housing and Urban-Rural Development of the People's of China (MOHURD) | http://www.mohurd.gov.cn/index.html |
| | China Institute of Building Standard Design & Research | http://www.cbs.com.cn/index_en.html |
| Food Safety | School of Food Science and Technology, Jiangnan University | http://foodsci.jiangnan.edu.cn/Index.asp |
| | China National Research Institute of Food & Fermentation Industries | http://www.cnif.cn/ |
| | China Food and Drug Administration | http://eng.sfda.gov.cn/WS03/CL0755/ |
| | Chinese Academy of Inspection and Quarantine | http://www.caiq.org.cn/eng/index.shtml |
| | China National Centre for Food Safety Risk Assessment | http://www.chinafoodsafety.net/ |
| Energy (electrical vehicle) | Tsinghua University, Department of Automotive Engineering | http://www.dae.tsinghua.edu.cn/publish/daeen/index.html |
| | College of Automotive Engineering, Jilin University | http://auto.jlu.edu.cn/english/ |
| | China Automotive Engineering Research Institute Co., Ltd. | http://en.caeri.com.cn/ |
| | School of Mechanical Engineering, Shanghai JiaoTong University | http://me.sjtu.edu.cn/English/Default.aspx |
| | State Key Laboratory of Automotive Safety and Energy | http://www.ase.tsinghua.edu.cn/publish/aseen/index.html |
| Big Data | Research Centre on Fictitious Economy & Data Science, CAS | http://www.feds.ac.cn/index.php/en/ |

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|---|---|---|
| | Renmin University of China, Institute of Statistics and Big Data | http://isbd.ruc.edu.cn/ |
| | School of Data Science, Fudan University | http://www.sds.fudan.edu.cn/wp/ |
| | Sun Yat-sen University, School of Data and Computer Science | http://sdcs.sysu.edu.cn/ |
| | Beijing Institute of Big Data Research | http://www.bibdr.org/en/index.jsp |
| Economy, Finance and Markets | Development Research Centre of State Council | http://en.drc.gov.cn/ |
| | Academy of Macroeconomic Research, National Development and Reform Commission | http://en.amr.gov.cn/en/ |
| | National Academy of Economic Strategy, Chinese Academy of Social Sciences | http://naes.org.cn/english/ |
| | Hanqing Advanced Institute of Economics and Finance, Renmin University of China | http://www.hanqing.ruc.edu.cn/eng/ |
| | Tsinghua University School of Economics and Management | http://www.sem.tsinghua.edu.cn/portalweb/appmanager/portal/semEN |
| Education, Skills and Employment | Faculty of Education, Beijing Normal University | http://fe.english.bnu.edu.cn/ |
| | Faculty of Education, East China Normal University | http://www.ed.ecnu.edu.cn/# |
| | Nanjing Normal University | http://english.nnu.cn/ |
| | Faculty of Education, Northeast Normal University | http://edu.nenu.edu.cn/plus/list.php?tid=99 |
| | Ministry of Education of the People’s Republic of China | http://english.nies.net.cn |
| Disaster Risk Management | Institute of Care-life | http://www.365icl.com/view.asp?pid=297 |
| | Academy of Disaster Reduction and Emergency Management, Ministry of Civil Affairs & Ministry of Education | http://www.adrem.org.cn/english.html |
| | Institute of Atmospheric Physics, CAS | http://english.iap.cas.cn/ |
| | China National Commission for Disaster Reduction | http://www.jianzai.gov.cn/DRpublish/ywzsy/00010023-1.html |
| | CAS-TWAS Centre of Excellence on Space Technology for Disaster Mitigation | http://www.castwas-sdim.org/ |
| Migration and Territorial Development | Renmin University of China, the School of Sociology and Population Studies | http://ssps.ruc.edu.cn/en/index.html |
| | The institute of Migration Studies, Shandong University | http://www.ims.sdu.edu.cn/index.htm |
| | Institute of Population and Labour Economics, The Chinese Academy of Social Sciences | http://iple.cssn.cn/english/ |
| | Department of Sociology, Peking University | http://www.sociology.pku.edu.cn/ |

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|---|---|---|
| | School of Social and Behavioural Sciences, Nanjing University | http://sociology.nju.edu.cn/en/ |
| Innovation Systems and Processes | Tsinghua University School of Economics and Management | http://www.sem.tsinghua.edu.cn/portalweb/appmanager/portal/semEN |
| | School of Management, Zhejiang University | http://www.cma.zju.edu.cn/en/ |
| | Institute of Policy and Management, CAS | http://english.ipm.cas.cn/ |
| | Chinese Academy of Science and Technology for Development, MOST | http://2015.casted.org.cn/en/ |
| | Torch High Technology Industry Development Centre, MOST | http://www.chinatorch.gov.cn/english/index.shtml |

Sources: The universities selected in this list are the top institutions in the official 2012 China Discipline Ranking, produced by the China Academic Degrees and Graduate Education Development Centre, Ministry of Education. The respective institutes of Chinese Academy of Sciences or Chinese Academy of Social Sciences and the most influential think tanks affiliated with various departments of the central government of China are also included in the list.

Notes:

1. MWR: The Ministry of Water Resources of the People's Republic of China
2. Focus on civil drainage research.

## Annex 2 - List of the main funding programmes

The main funding programmes in China are organized below under the Ministries which are responsible for managing the programmes.

### Ministry of Science and Technology

I. Major Research Programmes

| Name of the funding programme | Duration | Budget | Target group | Status in Future China's Research System (after 2017) |
|---|---|---|---|---|
| National Basic Research Programme (973 Programme) | 5 years | Type A: approx. RMB 50 million (€6 million) | Scientific institutes, universities or companies registered in mainland China with legal person status, strong basic research capability and conditions. | Merged into National R&D Key Program |
| | | Type B: approx. RMB 35 million (€4.2 million) | Outstanding foreign scientists from Hong Kong, Macao, Taiwan and overseas who meet the basic requirements and hold a formal position with a Chinese host organization. | |
| | | Type C: approx. RMB 15 million (€1.8 million) | key basic research projects in the field of agriculture, energy, information technology, resources and environment, population and health, and materials and etc. | |
| National High-Tech Research and<br><br>Development Programme (863 Programme) | ≤5 years | The total fund in 2009 was approximately €1.08 billion. | Cutting-edge technologies in certain key areas in the "National Long-term Scientific and Technological Development Plan (2006-2020)": information technology, biotechnology and medical technology, new materials technology, advanced manufacturing technology, advanced energy technologies, resources and environmental technology, marine technology, modern agricultural technology, modern transportation technology, earth observation and navigation technology and other high-tech areas. | Merged into National R&D Key Program |
| National Key Technologies R&D<br><br>Programme | ≤5 years | The total fund in 2009 was approximately €2.4 billion. | Focuses more directly on industrial needs in the following fields: energy, resources, environment, agriculture, materials, manufacturing, transportation, IT and modern service industry, population and health, urban development, public safety and other social affairs, among others.<br><br>Key project: focuses on significant social issues, and supports major national construction and equipment development;<br><br>Important project: focuses on regional development, and solves the bottle-neck issues in the industry and social development. | Merged into National R&D Key Program |
| National S&T Major Projects | Each S&T Major Project has | The government announced in | Address major technologies of strategic importance for the Chinese economy and overall competitiveness in the | Unchanged |

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|---|---|---|---|---|
| | its specific deadlines. | 2011 a financing plan of €4 billion for the National S&T Major Projects. | following fields: Advanced Digital Control Machines and Fundamental Manufacturing Equipment, Breeding of New Variety for Transgenic Biology, Core Electronic Devices, High-end General Chips and Fundamental Software, Key New Drug Innovation, Large-scale Development of Oil & Gas Fields and Coal-bed Gas, Mega-scale Integrated Circuit Manufacturing Technologies, Next Generation of Broadband Wireless Mobile Networks. | |

II. Policy Guidance Programmes

| **Name of the funding programme** | **Duration** | **Budget** | **Target group** | **Status in Future China's Research System (after 2017)** |
|---|---|---|---|---|
| Basic Science and Technology Specialized Project | a key project: ≤5 years<br>a general project: ≤3 years | a key project: ≤ €1.2 million;<br>a general project: ≤ €0.24 million | Scientific Investigation and Research:<br>a. General Scientific Research;<br>b. Specialized Scientific Project;<br>c. Scientific Investigation In Neighbouring Regions<br>Edit, Study and Illustration of S&T Materials:<br>a. S&T Materials Edit;<br>b. Classic Study and Edit;<br>Science Standard and Standard Materials Production. | Merged into National R&D Key Program |
| Agriculture S&T Achievement Industrialisation Fund | The length of each project should not exceed 2 years in general, while special one could be extended to 3-4 years and special key project generally should not exceed 4 years. | Budget for each project in 2012 is as follows:<br>General project: approximately RMB 0.06 Million;<br>Key project: approximately RMB 1 million;<br>Major project: approximately 3 million. | Aims to support the commercialization of<br>Technologies suitable to agriculture. It covers<br>mature, pragmatic technologies in the areas of<br>new crop or animal breeding, effective animal<br>farming, agricultural product processing, water<br>conservation and agricultural equipment | Merged into National R&D Key Program |
| National New Products Programme | 2-3 years | The annual budget for the Programme was approximately €24 million in 2011. | two categories:<br>1. Strategic New Products:<br>This category refers to major creative products that have strategic values in national economic growth, has great influences protecting and improving social life, promotes the local and industry development, possesses independent intellectual property | Merged into National R&D Key Program |

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|---|---|---|---|---|
| | | | right and strong market competitive advantages, in the national strategic new manufacturing fields, such as energy saving and environmental protection, new information technology, biotech, high end devices manufacturing, new energy, new materials and new energy vehicles, etc.<br><br>2. Key New Products:<br><br>This category includes new products in line with the national industrial development policy, having good sales record or prospect, major economic and social benefits, independent intellectual property rights and trademarks, high level of technology and added value, and strong market competitiveness. | |
| National Soft Science Research Programme | 2-3 years | the budget was approximately €2.5<br><br>million in 2008. | interdisciplinary fields of natural science, social<br><br>science and engineering technologies. Different<br><br>from result-oriented hard science research, the<br><br>soft science research concentrates on<br><br>exploratory research. | Merged into National R&D Key Program |

III. Other Programmes

| **Name of the funding programme** | **Duration** | **Budget** | **Target group** | **Status in Future China's Research System (after 2017)** |
|---|---|---|---|---|
| International S&T Cooperation Programme (ISTCP) | a key project: ≤5 years<br><br>a general project: ≤3 years | In 2008, the total fund was approximately €40 million.<br><br>A project under the Special funds programme can be funded with no less than approximately €0.5 million, while a project under the Bilateral S&T cooperation programme between governments will normally be funded up to approximately €0.1 million. | Inter-governmental science and technology cooperation projects based on bilateral or multilateral agreements, promoting China's science and technology, economic and social development;<br><br>High-level international cooperation projects catering to the needs of national economic and social development and national security, in line with the policy objectives of the country's external scientific and technological cooperation, aiming to solve major scientific issues restricting China's economic and technological development; International cooperation projects with first-class foreign research institutions universities and enterprises to carry out | Merged into National R&D Key Program |

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| | | | cooperation in research and development, attracting outstanding overseas talents and teams to work in China, promoting China's international scientific and technological cooperation base construction, and strengthening China's capacity of indigenous innovation. | |
| EU-China SME energy conservation and emission reduction research collaboration fund | | The maximum funding for a R&D project will be 40% of the project budget or €0.36 million;<br>The maximum funding for an exchange project will be 50% of the total international travel expenses or €0.036 million per SME. | support Chinese SMEs to collaborate with EU enterprises and research institutes (hereinafter referred to as EU partners) and carry out joint research, technology transfer and re-innovation, commercialization of research results in the field of energy conservation and emission reduction to promote China's technological advancement. | Merged into National R&D Key Program |

### National Natural Science Foundation

| **Name of the funding programme** | **Duration** | **Budget** | **Target group** |
|---|---|---|---|
| General Programme | 3 years | In 2011, the total budget was approximately €1.1 billion. | Mathematical and Physical Sciences<br>Chemical Sciences<br>Life Sciences<br>Earth Sciences<br>Engineering and Materials Science<br>Information Sciences<br>Management Sciences<br>Medical Science |
| International (Regional) Cooperation and Exchange Programme | Not available | Each programme has its specific budget. | Strategic cooperation with overseas funding organizations to promote the implementation of substantial bilateral and multilateral joint research projects. In addition, it provides financial support to major international (regional) cooperation projects, talent exchange and conferences. |
| Joint Funds Programme | Not Available | Each Joint Fund has its own budget. | Scientists from all natural science and management science disciplines can choose a research topic within the scope of the Joint Funds Programme. The funds under the Joint Funds Programme include:<br>1. NSAF Joint Fund<br>2. Joint Fund of Astronomy<br>3. Joint Fund of Research utilizing Large-scale |

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|---|---|---|---|
| | | | Scientific Facilities<br>4. NSFC-Guangdong Joint Fund<br>5. NSFC-Yunnan Joint Fund<br>6. Joint Fund of Civil Aviation Research<br>7. Joint Fund of Iron and Steel Research<br>8. Joint Fund of Coal Research<br>9. NSFC-Xinjiang Joint Fund<br>10. NSFC-Henan Talent Development Joint Fund |
| Joint Research Fund for Overseas Chinese Scholars and Scholars in Hong Kong and Macao | the applicant will work in the host organization for more than two months every year. | In 2012, the budget per applicant is<br>Approximately €24,000 for two years with the possibility of prolongation. | Overseas Chinese Scholars and Scholars in Hong Kong and Macao from all disciplines can apply. |
| Key Programme | 4 years | In 2011, the total budget was approximately €174 million | Global frontier research, innovation resources<br>Integration and scientific key breakthrough. |
| Major Research Plan | three years for Fostering Project, and four years for Key Funding Project. | approximately €0.05 million each. | Form groups of projects with similar goals to solve key scientific issues with strategic importance to the country and to advance in key areas. |
| Young Scientists Fund | 3 years | In 2011, the total budget was approximately €0.38 billion. | fostering young talents, supporting independent research, stimulating creative thinking and strengthening the capability of young scientists of organizing a research team. |

Note: National Natural Science Foundation will remain unchanged in the future China's Research System (after 2017).

**Chines Academy of Sciences**

| **Name of the funding programme** | **Duration** | **Budget** | **Target group** |
|---|---|---|---|
| Einstein Professorship Programme | one or two weeks | The Einstein Professorship Programme plans to support 20 applicants each year. The grant covers the cost of accommodation and<br>transportation in China; A round-trip international airfare between the airport located nearest to the visitor's home and that nearest to the host institute; An honorarium of approximately €1,145 for giving a lecture tour. | Distinguished international scientists actively working at the frontiers of science and technology |
| Fellowships for Young | 12 months | Candidates at the research scientist level, under the | young scientists from all |

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|---|---|---|---|
| International Scientists | | age of 40, will receive up to €30,000 per year. Post-doctoral candidates, under the age of 35, will receive up to approximately €18,000 per year; | disciplines<br>can apply. |
| Visiting Professorships for Senior International Scientists | 2-12 months | A candidate who is currently a professor or equivalent, including those who have received a world-class award such as a Nobel Prize or equivalent, will receive up to €61,000 a year.<br>A candidate of lower academic position such as an associate professor or equivalent will receive up to approximately €49,000 a year | senior scientists from all disciplines<br>can apply. |

Note: The Chinese Academy of Sciences will remain unchanged in the future China's Research System (after 2017).

**Chinese Scholarship Council**

| **Name of the funding programme** | **Duration** | **Budget** | **Target group** |
|---|---|---|---|
| CHINA/UNESCO - the Great Wall Fellowship | Not Available | total budget of no less than approximately €0.05 million for the academic year 2010/2011.<br>General Scholars: approximately €207 per month;<br>Senior Scholars: approximately €244 per month. | Foreign scientists from all disciplines can<br>apply. |
| Chinese Government Scholarship Scheme | 2-7 years | €170-240 per month | Scientists who are non-Chinese citizens from all disciplines can apply. |
| Distinguished International Students Scholarship | Not Available | Master's degree students: approximately €207 per month;<br>Doctoral degree students: approximately €244 per month. | International students currently studying in the designated Chinese HEIs and in good health. |
| University Postgraduate Programme | Not Available | Master's degree students: approximately €200 per month;<br>Doctoral degree students: approximately €240 per month. | Foreign scientists from all disciplines can<br>apply. |

Note: The Chinese Scholarship Council will remain under the administration of the Ministry of Education in the future China's Research System (after 2017).

Data: National Funding Programmes in Mainland China (http://www.access4.eu/China/274.php)

## Annex 3 - Evaluations, consultations, foresight exercises

Institutions in China conducting evaluation, consultations and foresight exercises include:

**National Centre for Science and Technology Evaluation** (http://www.ncste.org/)

**Chinese Academy of Science and Technology for Development** (http://2015.casted.org.cn/cn/)

The **Chinese Academy of Sciences** (www.cas.cn)

The CAS foresight report "Innovation 2050: Science, Technology and the Future of China" is published on paper, (not available online).

The **Chinese Academy of Engineering** (www.cae.cn)

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*Serving society*
*Stimulating innovation*
*Supporting legislation*

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